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Three Gorges Dam Gets Go-Ahead

*40100030A Beijing CHINA DAILY in English
4 Apr 92 p 1*

[Article by staff reporter Li Hong: "Three Gorges Dam Gets Go-Ahead; Draft Laws Approved at NPC Session"]

[Text] The Seventh National People's Congress (NPC) concluded its fifth, and last, session yesterday in Beijing, endorsing the State Council's government work report, three draft laws, and also giving the go-ahead to the long-disputed Three Gorges dam project.

The 15-day meeting of China's legislative body, beginning March 20, has largely been guided by the recent statements of veteran leader Deng Xiaoping, advocating an open-minded and bolder approach in building socialism with Chinese characteristics.

The government work report, delivered by Premier Li Peng, was approved with an overwhelming majority, but after more than 150 changes were made during the deliberation by nearly 3,000 deputies.

Of the 2,633 deputies attending yesterday's closing session held in the Great Hall of the People, 1,767 voted in favour of the 57-billion yuan ($10.5 billion) Three Gorges dam project on the Yangtze River, while 177 voted against, and 664 abstained.

Also approved at the meeting were the government's 1992 draft plan for economic and social development, the 1992 State draft budget, and an election programme for deputies to the Eighth NPC, which will convene next year.

Also passed at the final session were the Trade Union Law—which ensures that China's working classes are masters of the country—the Law on the Protection of Women's Rights and Interests—which guarantees women's equality with men—and the Law on Deputies of the People's Congress at All Levels—which was designed to improve the people's congress system.

Premier Li Peng's government work report, much shorter compared with previous years and having been revised on the opinions solicited from the deputies, is "based on facts," the session said. Of the 2,936 deputies present yesterday, 2,583 voted for it.

The report calls for adhering to the Party's basic line, and never losing sight of the central task of economic development. It emphasizes stepping up reform and opening wider to the outside world, the session said.

The work report says that it is important for China to draw on the achievements of civilizations the world over, and take in both planning and market forces, two methods of running an economy.

"It is crucial for cadres at all levels to further enhance their consciousness of implementing the Party's basic line and guard mainly against 'leftist' deviations, while watching out for 'rightist' deviations," the revised report said.

The Communist Party's basic line, which focuses on economic construction, must remain unwavering for 100 years, it said.

Li's work report said that it is imperative for China to have several periods of higher economic growth and better economic performance in its modernization drive.

"If work in all fields is done better this year, there will be a more solid foundation for a faster development in the economy in the last three years of the Eighth 5-Year Plan period (1991-95)," an amendment to the report said.

On the role of the share-holding system, the revised report added that the system "will help change the methods of operation of enterprises."

The government must continue to give play to the useful and supplementary role of the individual and private sectors, the report said.

Yesterday's session demanded that the State Council and local governments at all levels make all-out efforts to carry out the tasks put forward in the government work report.

The annual NPC session voted to dam the 6,300-kilometre-long Yangtze River, the third longest in the world.

It decided to include the gigantic project in the country's 10-year (1991-2000) programme for national economic and social development, and authorize the State Council to implement it at an appropriate time, in light of China's actual conditions and its financial and material strength.

The session stressed continuous research and accurate resolving of problems.

This is the first time the Chinese Government has submitted a major project proposal to the NPC for deliberation and approval.

The dam project, proposed by the State Council, was said to be "essential for the promotion of the overall national strength, and will lay a solid foundation for national economic development in the next century."

Further Preparation on Three Gorges Dam Project Planned

*40100031 Beijing CHINA DAILY in English
6 Apr 92 p 1*

[Article by staff reporter Gao Anming]

[Text] Construction of the colossal Three Gorges Dam will start "some time in the 1990's", a leading official announced on Saturday—a day after the project was endorsed by the country's top legislature by a two-thirds majority.

But Water Conservancy Minister Yang Zhenhuai ruled out the possibility of an immediate start saying time was needed "to study further some lingering questions, design the project, resettle local residents and work out financial plans."

Yang, who also heads the State Commission for Reviewing the Three Gorges Project, said: "It is difficult to tell when the project will actually start. It is up to the State Council to choose an appropriate time in the light of the nation's material and economic resources."

On Friday, the closing session of the National People's Congress approved listing the dam in the country's 10-year program for economic and social development (1991-2000) after 1,767 legislators voted for the project, 177 against and 664 abstained.

Yang told a news conference on Saturday that he was satisfied with the voting results, adding: "It was in line with democratic procedures."

"We fully understand and respect those who abstained because of doubts on the project or other reasons," Yang said. "But abstentions do not necessarily mean the delegates are against the project.

"We will provide all sectors of society with detailed material and research findings from the past decade, and we welcome, respect and will treat seriously different views at all times, even when the project has actually started."

The Minister pledged further research into unresolved issues, especially those which caused concern among NPC deputies and various social circles.

On financing, it is estimated that 44 percent of the investment will come from the project itself as it starts generating electricity in the ninth year of construction, and the revenue from the Gezhouba hydroelectric power station, said You Jiahou, head of the project's economic feasibility study group.

The government is expected to devote part of its planned capital construction fund and its budgetary spending on the project, too, but that "only makes up a small proportion," You said.

The government plans to impose a special electricity tax on areas that will benefit from the proposed dam, issue bonds and shares, and use overseas loans on favorable terms, You said.

But neither You nor Yang revealed how much China will borrow from overseas investors.

The government will start issuing bonds and shares once the State Council establishes a steering group to coordinate and supervise the project, Yang Zhenhuai said.

The government has already earmarked money for further studies and trial resettlement programs for this year but he gave no details.

"China has the ability to build the dam," Yang said, "but in line with our policy of reform and opening to the outside world, we want the world's most advanced technology and equipment for the dam."

Potential Energy Crisis in China

926B0068a Beijing ZHONGGUO NENGYUAN [ENERGY OF CHINA] in Chinese 25 Feb 92 pp 4-5

[Article by Zhou Dadi [0719 1129 0966] and Chu Ming [0443 2494], State Planning Commission and Energy Research Institute, CAS: "Potential Energy Crisis in China"; first installment]

[Text] Population, agriculture, energy, and the environment are problems that almost all developing countries must face in the course of their development. China's government has taken many concrete steps in an effort to solve the problem of energy supply and demand, but for about the last decade, economic development has constantly been constrained by energy shortages, whose effect has been gradually worsening. An even greater cause of concern is that several of the basic factors that have given rise to energy shortages have persisted, and that in some respects we are worse off then we were 10 years ago. Although the economic slump of the last 2 years has produced some temporary alleviation of the energy supply and demand problem, when a significant upturn of industrial output occurs, the severe shortfall that we experienced before last year will return with increasing severity.

I. China's Energy Shortage Is Extremely Serious

China's energy shortage is a long-term, persistent, cyclic problem.

Consider, for example, the shortage of electric power. In the 40 years from 1949 to 1989, there were shortages in 25 years, including short-term shortages in the Beijing-Tianjin-Tangshan area in 1953, in 23 areas of the country in 1956, and throughout the country in 1958-60. But from 1970 until the present, there has been a long-term, nationwide electric power shortage. The geographic extent and magnitude of the shortfall have gradually increased; during the first 4 years of the Seventh 5-Year Plan in particular, cutoffs of electric power became increasingly frequent and covered larger and larger areas, not only causing great economic loss, but also directly affecting the people's livelihood and contributing to increasing instability.

Experts state that China's current electric power generating capacity is more than 17 GW [gigawatts], but the shortfall in electric energy output exceeds 70 TWh [terawatt-hours]. Some experts estimate that the actual shortfall in electric power generating capacity is nearly 70 GW and that the shortfall in electric energy output exceeds 190 TWh. In other words, the shortfalls in both power generating capacity and electrical energy output exceed 15 percent. A shortfall of this magnitude cannot be eliminated quickly.

The main direct cause of the electric power shortfall is insufficient generating capacity; an inadequate coal supply is also a major factor. During the Sixth and Seventh 5-year plans, there were two nationwide coal shortages. The rapid development of the east coast in the period through 1985, in which the provincial and municipal heads took the lead and all manner of attempts were made to step up coal output, is still fresh in people's minds. Local coal mines, and especially rural and township coal mines, were developed on a large scale, and for a time they alleviated the coal shortage. But this improvement was short-lived: a ubiquitous coal shortage that began in 1988 lasted more than 2 years. In some cases, piles of gangue that had been accumulating for many years at major coal mines were actually sold as coal to desperate users. Experts conclude that the annual increase in coal output lagged behind the increase in demand by more than 10 million tons, and that the cumulative shortfall over the Seventh 5-Year Plan was 70 million tons.

Petroleum and petroleum products have long been in short supply and subject to use restrictions. Since the Sixth 5-Year Plan, the government has maintained a comprehensive policy of decreasing the combustion of oil. But starting in 1986, shortages of electric power and a variety of rational and essential requirements for the combustion of petroleum products have created a steadily increasing pressure, with the result that the burning of oil has again been on the increase. In terms of state policy, the primary use of petroleum is for mobile machinery (motor vehicles, boats, aircraft, tractors and the like) and as an essential chemical feedstock. From 1980 to 1988, China's domestic gasoline supply increased by 79.2 percent and its kerosene supply by 55.3 percent, but civilian motor vehicle ownership grew by 133.2 percent, and boats in the civilian sector by 142.7 percent; there were also significant increases in other types of internal-combustion machinery, and the supply of all petroleum products fell short of demand. The result is that, at present, while there has been a temporary alleviation of the coal and electric power shortages, the supply of petroleum products is still rather tight.

Natural gas, which is now the third-largest and the fastest-growing energy resource worldwide, has been all but ignored as a component of the energy balance in China. In the last 10 years, natural gas output has dipped and has finally returned to the 1980 level. The question of whether it should be used in the civilian sector or as a chemical feedstock has been debated for many years by energy experts. In either use, its social benefits are highly significant. The crux of the problem is that China's current natural gas output is only a minuscule fraction of the potential demand.

II. Future Energy Resource Prospects Are Grim

Current mid- and long-term energy forecasts are that the energy supply will remain extremely tight for a rather long period.

A. The pace of economic development will remain high for the next 10 years. In order to meet the development objectives for the year 2000, our economic growth rate must be significantly above the world average. Owing to steady population growth and the fact that the current size of the rural population still greatly exceeds agricultural manpower needs, there is tremendous pressure to move to industry and to the third sector [i.e., the service sector]. Furthermore, China's basic facilities are still extremely backward, economic growth by the extensive model of expanded reproduction will still retain its primacy, and investment in fixed assets will remain the chief factor driving economic growth for a long time to come. Many experts in China and abroad estimate that if China's rate of economic growth recovers, the annual growth rate of the economy over the next 10 years can still exceed 7 percent.

B. China's current level of energy consumption is still extremely low, lagging far behind not only the industrially developed countries, but also behind the world average. Based on the 1988 energy consumption rate and a population of 1.09 billion persons, China's per capita consumption of primary energy resources is 852,000 grams of standard coal, only 36 percent of the world average figure; per capita coal consumption is 647,000 grams of standard coal, or 95 percent of the world average; per capita petroleum consumption is 144,800 grams of standard coal, or 16.8 percent of the world average; and per capita consumption of natural gas is 17,700 grams of standard coal, or 3.9 percent of the world average. The per capita consumption of electric power is 500 kWh, or 24.2 percent of the world average.

C. There have been many energy requirement forecasts for China's provinces, municipalities and regions, and all of these figures far exceed anything that could be met by the country's energy resource development targets. National energy demand predictions generally make thorough allowance for energy supply conditions and place great hope in the potential offered by energy conservation; although their results differ, the great majority predict that the demand for primary energy resources in the year 2000 will be more than 1.5 billion tons of standard coal, considerably above the figures envisioned by the current energy development program.

D. The energy industry is hard-pressed everywhere and lacks a driving mechanism capable of accelerating its development. The energy industry's financial condition is universally worse than it was 10 years ago. The coal industry is losing money across the board, up to a billion yuan per year. Increases in coal production have relied chiefly on the rapid development of rural and township mines, but their staying power has consistently been disappointing. The petroleum industry entered the ranks of across-the-board money losers in 1988. Current investments are sufficient only to maintain current output levels. Many experts believe that under current conditions the petroleum and natural gas output projections for the year 2000 are unattainable. Although the electric power industry has been developing rather rapidly in the past 3 years, its profitability rate fell from 13 percent in 1980 to 5.8 percent in 1988. Hydropower development has been the chief victim of the power industry's inability to finance its own development. To achieve the objective of having hydropower provide 20 percent of total electric power output by the year 2000, it will be necessary to commission more than 3.5 million kilowatts of hydroelectric power stations every year for the next decade; otherwise, the shortfall of primary energy resources will increase further. But at present, less than 2 million kWh of hydropower capacity is being commissioned each year.

Development of Oil, Gas Prospecting in China

926B0068B Beijing ZHONGGUO NENGYUAN [ENERGY OF CHINA] in Chinese 25 Feb 92 pp 6-8, 5

[Article by Chen Juan [7116 6855/0656/5131], Institute of Petroleum Prospecting and Development: "Oil and Gas Prospecting and Development in China"]

[Text] The petroleum industry is a major pillar of China's economy, and oil and gas are major strategic materials which not only directly affect the development of the energy, defense, chemical engineering and transport sectors, but also agriculture and other industries; they are products with great processing value and with great upvaluation potential as well as major resources by which China can create foreign exchange.

I. Oil and Gas Prospecting Is Achieving Splendid Results and Has Extensive Prospects

Resource evaluation is been performed on 143 Paleozoic, Mesozoic and Cenozoic basins on dry land and on the continental shelf (including 3 marine-facies sedimentary regions), with a total area of 4.5 million square kilometers. Since the state was founded, spectacular progress has been made in geological prospecting for oil and gas, including the discovery of 441 commercial oil and gas fields in 19 basins, and explored geological reserves of oil and gas are much greater than they were before liberation. The scope of oil and gas prospecting is broad, but its thoroughness is variable and generally low. In East China, circumstances are favorable for the steady discovery of large oil and gas fields in shallow seas and other offshore regions, and there is a possibility of finding complex or deeply hidden oil and gas or pools in older basins and in new medium-size and small basins, e.g., pools with complex pay strata, complex lithology, or complex small-block structure, as well as low-permeability, low-productivity, or superdeep medium and small-size oil and gas pools or pools of thick oil. There is some prospect for finding large and medium-size oil and gas fields in the west and in extensive sea basins (e.g., at the mouth of the Pearl River, in the Yinggehai and Beibuwan areas, southeast of Qionghai, in the Donghai and southern Yellow Sea areas, in the Taixi basin and the like). The surface conditions in the areas are difficult or even dangerous, climatic conditions are variable and complex, and the locations are socially and economically underdeveloped border regions; the unique problems that they present spring from the above factors and from geological complexities, e.g., complex structural conditions, unusual trap types, a variety of pool types, complex pay stratum structure, a diversity of pay stratum types, pay strata at great depths. But these very large or large oil-containing basins are sure to contain medium and large-scale oil and gas fields of relatively simple structure that are ready for development. During the Seventh 5-Year Plan, excellent oil and gas prospects were found in the Tarim Basin, including the Lunnan area (where commercial pools have already been found), the Taizhong region, and the Yingmaili region, but under conditions that are relatively complex; major breakthroughs have been made in the Turpan Basin, and the Shanshan oil field and the Qiuling and Yilahu regions have significant reserves; important breakthroughs have also been made in the eastern Dzungarian basin, including the Huoshaoshan and Beisantai oilfields; offshore, some medium and large-scale oil and gas accumulations have been found at the mouth of the Pearl River and in the Yinggehai Basin. To make comprehensive breakthroughs in the above basins and get at the main oil and gas pools will require time and unremitting hard work, as well as personnel, advanced scientific and technology, modern and well-rounded suites of equipment and an appropriate management system; but ultimately, it will need to be supported by extremely large investments.

II. Oil and Gas Production Is Expanding Rapidly, But Under Trying Circumstances

In the 42 years since the state was founded, China has made great strides in oilfield development and production. More than 20 oil and gas production bases have been established, and as of the end of 1990, China had a crude oil production capacity of 141 million tons and a natural gas production capacity of 15 billion cubic meters. We entered the ranks of the world's major oil producers in the early 1980's. China's oil and gas extraction technology is advancing rapidly, and oilfield development has reached a rather high level. The rate of oil extraction has consistently been rather high, so that the natural annual rate of decline in oilfield output is 0.86-0.84 and the overall annual rate of decline is 0.943-0.923. Calculating from the overall rate of decline, the cumulative decline in production over 5 years is 43.41 million tons, while newly added oil producing capacity over the same period is 78.08 million tons, giving a cumulative net increase in production capacity of 34.67 million tons and a real cumulative increase in oil output of 13.38 million tons, equivalent to an annual average net increase in output of 2.68 million tons. In 1988 and 1990, the net annual increase in output was only 620,000 tons. The Eighth 5-Year Plan requires that the output of crude oil be increased from 138 million tons in 1990 to about 145 million tons in 1995 and that an effort be made to achieve a rather large increase in production by the year 2000; but in view of the real net annual increase in output, this is a rather large and difficult gap. Thus, maintaining a stable output of crude oil and increasing production will be a rigorous task. The recoverable reserves newly added during the Seventh 5-Year Plan were far below the amount of oil extracted during the same period; the reserves-to-output ratio in 1990 was 2.87 percent lower than that for 1985, which indicates what an arduous task of increasing recoverable oil reserves lies ahead.

III. Increase Investment in Prospecting, Increase Reserves

During the Seventh 5-Year Plan, inadequate funding greatly constrained prospecting activities and technological development, so that during this period there was actually a relative contraction of prospecting activity that directly hindered the effort to increase explored oil and gas reserves. During the Seventh 5-Year Plan the nominal investment in prospecting increased by 78 percent over that of the Sixth 5-Year Plan, but if we correct for an increase in material costs and operating costs, increased difficulty of prospecting and the like, the real increase in investment was very small; as a result, the total amount of prospecting work performed was nearly at the same level as during the Sixth 5-Year Plan, exploratory well footage was only 51 percent of the target, and the total amount of explored oil and gas reserves added to the books was 74.2 percent of the target; the investment required for the addition of 100 million tons of explored reserves was twice that required in the Sixth 5-Year Plan, and the actual investment amount fell about 12-16 billion yuan short of what would have been required for attainment of the Seventh 5-Year Plan targets.

It is evident from the above figures that although in overall terms China's oil and gas reserves are rather abundant and a relatively small fraction of them has been explored, our per capita oil and gas reserves are actually rather small. As a consequence, we must intensify efforts to develop and utilize our limited, precious, scarce oil and gas reserves, and in the course of economic development we must step up our attempts to find their best strategic utilization.

Ultimately, the development of the oil and gas industry depends on geological prospecting. If no progress is made in this activity, there will be no increase in the oil and gas reserves on the books, so that it will become impossible to correct the current situation, in which the ratio of reserves to extraction is declining, maintaining steady output is difficult, and increasing output is problematic. Thus, stepping up all aspects of prospecting and increasing the explored geological reserves of oil and gas still constitutes the central task on the petroleum front.

Progress in oil and gas prospecting requires huge investments; otherwise, it will be difficult to reverse the current relative contraction of prospecting work. Consequently, facilitating funding channels for prospecting, universally instituting the compensated use of resources, and fully including exploration costs in crude oil production costs are the correct ways of moving prospecting work into a beneficial cycle.

IV. Some Problems in the Technical and Economic Evaluation of Oil and Gas Resources and Some Suggestions for the Future

In order to further strengthen the management of oil and gas resources and to improve technical and economic analysis, the National Mineral Resources Commission decided that in 1988 it would begin nationwide trial implementation of temporary regulations for the technical and economic evaluation of oil and gas reserves. Technical and economic evaluations of the explored reserves of 35 oil and gas fields over the past 2 years have not produced encouraging results. Under the requirement for comprehensive economic evaluation, an economic evaluation of the prospective economic benefits from future industry development indicated that even if compensated utilization of reserves were instituted and if new selling prices were calculated at parity, the internal earnings rate would be essentially negative, and that the unit production cost of commodity oil or gas evaluated by the total-cost method would be significantly higher than the current parity value. This result indicates, at the very least, that the exploration, development and capital-construction components of industry consumption and expenses have not been fully included in production costs, and that in fact less than half the value of these components has been included: thus, on the basis of the current compensated resource utilization fees, it would be possible to raise only about 40 percent of the funds needed annually for exploration. These results indicated that unless effective arrangements for funding prospecting were made, unless prospecting efforts were strengthened and the amount of prospecting work was increased, and unless investments in prospecting were guaranteed, it would become difficult to maintain a steady growth of oil and gas reserves and to increase output. Another problem that emerged from the economic evaluation of reserves was that even if the selling price were calculated in terms of the current high price, the economic benefit from future industry development of newly added reserves would have about ⅓ the profitability rate of newly added reserves, falling short of the standard industry profitability rates prescribed for the economic evaluation, and the technical and economic evaluation of newly added oil reserves from the main area of effort in the west and from offshore areas would essentially have to be based on "shadow prices" or international prices. Thus, two problems are evident. The first is that the petroleum industry must use a comprehensive economic accounting procedure that takes account of the entire process, from prospecting to development and production (where "comprehensive" implies industry economic accounting that encompasses the entire process and all personnel). Oil prospecting accounts for about one-third of total petroleum industry expenditure and is the spearhead of the entire petroleum production process; thus, prospecting costs must be incorporated into crude oil production costs by the full-cost method (i.e., considering enterprise product output and product sales, the so-called "sum of consumption and expenditure"). This is the only way to meet the requirements for comprehensive economic accounting and to make an objective, realistic analysis of the economic conditions and environment that China's petroleum products encounter and of the position that their macroscopic and microscopic benefits occupy in the context of major cycles on foreign markets, so that it becomes possible to consider specifically targeted, scientifically and technically based, management-based and economically based measures and to find an effective policy for decreasing production costs, improving quality, and increasing economic effectiveness. Second, we must rationalize the sales prices of oil and gas products in timely fashion; once these prices are rationalized, the petroleum industry will be able to function as an important pillar of economic development and increased state accumulation while continuing its own self-funded accumulation and development. The petroleum industry's implementation of comprehensive economic accounting and the rationalization of oil and gas commodity prices must be carried out thoroughly and simultaneously: otherwise, the funding channels for prospecting, development and capital construction will remain closed or will be incompletely opened, and as a result, the petroleum industry's development will be unlikely to enter a beneficial cycle. We therefore suggest that the first step should be the institution of new prices for new oil and gas; that where a basic output level has been contracted for, output above this level should still be marketable at the current high price; and that in contracting for a base output level, 25 percent of output should be adjusted to the current high price each year. The purpose of these proposed changes is to assure that the oil and gas commodity selling prices are rationalized during the Eighth 5-Year Plan (the new prices can be provisionally set in terms of the current high price). This policy readjustment should bring significant benefits in four areas.

A. Alleviation of the burden on state finances and implementation of self-financed accumulation and development. In 1990, petroleum exploration funds were more than double the level of the Sixth 5-Year Plan. As prospecting becomes more difficult and the amount of work that is needed increases, prospecting expenses will rise from year to year: thus, to increase total explored reserves of oil and gas by 45 to 50 percent by the year 2000 will require an increase of about 10 billion yuan in funds for prospecting. If prospecting expenses are incorporated into the production cost of crude oil, if selling prices are rationalized so that funds spent on prospecting are recovered and are used earmarked especially for prospecting, this will increase the oil and gas industry's backlog of reserves, help maintain a rational reserves-to-extraction ratio, and increase the petroleum industry's ability to maintain a steady rate of growth.

B. Rational utilization of oil and gas resources and reserves. China has long followed the policy of "no price for minerals, low prices for starting materials, and high prices for manufactured goods," the result of which has been the uncompensated use of mineral resources. Oil and gas are no exception, and since in addition the ratio of the prices of crude oil and refined oil is low, this promotes high energy consumption, high production costs, low profitability rates, the operation of small refineries with obsolete processes and technologies, and ill-considered development of local refineries. In addition, oil for combustion makes up a large fraction of the consumption structure: in 1990 the amount of oil burned was equivalent to the output of several medium-sized oil fields. This situation does not promote the rational utilization of our precious oil and gas reserves: it actually stimulates increased consumption or even waste of oil and gas resources and brings about ecological damage and environmental pollution. If the petroleum industry implements comprehensive economic accounting and simultaneously rationalizes selling prices, this will promote technological progress in refineries, will increase profitability rates, will result in a wider range of product varieties and improved quality, and will increase the comprehensive utilization rate, which will foster a greater desire to be competitive on foreign markets, produce an overall restraint on the economy's demand for petroleum, and bring about a changeover to an energy-conserving economy.

C. Thorough mobilization and utilization of existing explored reserves. If the petroleum industry implements comprehensive economic accounting and concurrently rationalizes the selling prices of oil and gas products, the extraction industry will have an incentive to carefully design and organize the bringing of oilfields, tracts and pay strata into production, to make integrated adjustments of production activity in older regions, to improve the dynamic situation in zones under development, to overcome an excessive concern with short-term benefits, to organize rational development, and to make thorough use of existing reserves in order to increase the ultimate resource recovery rate of oil and gas fields. In addition, when there is relatively ample funding for prospecting, development and capital construction, the extraction industry will respond by bringing hard-to-develop explored reserves that involve high production costs and long mobilization times into production in stepwise fashion, so that they produce the proper resource benefits and economic and social benefits. Adequate funding of prospecting will also make the extractive industry take the initiative in correcting the current low level of companion natural gas production capabilities and the low natural gas commodity conversion rate.

D. Implementation of a focused investment policy. The suggested changes will promote the concentration of financial resources in order to organize key breakthrough efforts in prospecting activities and in major scientific and technological areas with the objective of achieving advances. If the share of natural gas both in the overall energy output structure and in the energy consumption structure were increased by 3 percent, the resource benefits, environmental benefits and economic benefits would be considerable. In addition, concentration of financial resources, self-reliant and self-supporting development of technology for offshore oil and gas exploration and extraction, and an accelerated pace of offshore oil and gas development would bring about concurrent, coordinated increases in both explored reserves and the output of oil and gas, thus yielding great resource benefits and economic benefits.

Qinghua University Nuclear Energy Research Institute Reorganizes

926B0072B Beijing GUANGMING RIBAO in Chinese 16 Feb 92 p 2

[Article by Reporter Ma Xuquan [7456 2700 3123]: "Qinghua University Nuclear Energy Research Institute Blazes New Management Trail"]

[Text] The Nuclear Energy Design and Research Institute of Qinghua University has scored remarkable success in reforming its internal management. The number of working personnel in the institute has been cut by more than half; the percentage of intellectuals increased from the former approximately one-half to two-thirds of the total number of personnel; and the per capita investment in scientific research increased from 100 to more than 40,000 yuan per year.

In 1984, the Nuclear Energy Institute (the predecessor of the Nuclear Energy Research Institute) put into effect a responsibility system for the head of the institute and for the directors of all laboratories, as well as an appointment system for all professors, staff members and workers. In 1988, the research institute put into effect a matrix style work management system for the two research laboratories for its reactor project, dividing them into five laboratories by academic specialty. This greatly spurred progress in building a 5 megawatt low heat nuclear reactor for supplying heat. At the same time, the institute instituted a system whereby personnel within the institute could move from one position to another. This enabled an optimization of personnel groupings. The institute also divided working personnel into three categories on the basis of their work attitude, abilities, and achievements, namely regular appointments, trial appointments, and candidate appointments, thereby spurring lagging comrades to change their ways. In the course of management reform, the nuclear research institute emphasized the key evaluation link, using different evaluation methods for professors, workers, administrators, and researchers, and for staff and logistical personnel.

Management reform at Qinghua University's Nuclear Design and Research Institute has effectively aroused the initiative of all professors, staff members, and workers. It has spurred along academic leaders, and has steadily improved the skills of key cadres in all positions. Young professors have matured rapidly, and some production experts have also come to the fore among workers.

Experts Urge Priority Study of Overall Electric Power Policy

926B0072A Beijing GUANGMING RIBAO in Chinese 16 Feb 92 p 2

[Article by Correspondent Zhai Huisheng [5049 1920 3932]: "More Than 100 Experts Including Sun Jiaping [1327 0857 1627] Propose Priority Study of Overall Electric Power Policy"]

[Text] By the year 2000, China will have 240 million kilowatts of installed electric power capacity, enough to support only a 5 percent increase in GNP, but not enough for 6 percent or more growth. Therefore, a far-reaching and pervasive study centering around electric power, should be made of overall policy making for energy production in order to provide sufficient scientific data to assure the coordinated development of the electric power industry and the national economy. This proposal was jointly made by high ranking engineer Sun Jiaping and more than 100 experts in the Water Conservancy and Electric Power Information Office.

The purview of a study of overall policy making in the electric power industry includes rational use of energy, understanding the correlation to the ecological environment of the development of energy and electric power, obtaining rights to environmental space, and how to make the energy and electric power management system meet needs for development of the national economy, etc. The experts proposed that during the Eighth 5-Year Plan period, the goal in studying overall electric power policy making should not be limited to the year 2000, but should look beyond. First, while studying the development of thermal power, ways and means of developing water power to the full, and active development of nuclear power should also be studied, with special emphasis given to the problem of greater environmental protection in the generation of thermal power. Second, emphasis should be placed on the conservation of energy and greater investment of funds in conservation, efforts made to develop and spread new energy-saving techniques and new technology, and to encourage the development of energy saving and multiple energy source types of household electric products. Third, in order to provide customers with ample, reliable, equitable, and cheap electric power, study should be devoted to the industry's internal operating mechanism and management methods, including how to continue and how to manage well the pooling of funds to run power plants, how to improve the electricity pricing system and straighten out electricity prices, and how to raise funds for the renovation and technological transformation of electric power supply equipment, thereby expanding electric power enterprises self-management, operating initiative, and self-development capabilities, and introducing electronic computer quantitative simulating techniques.

Guizhou To Add Over 5 Million kW in Next 10 Years

926B0058D Guiyang GUIZHOU RIBAO in Chinese 15 Dec 91 p 1

[Article by Zhang Junyan [1728 6511 3643]]

[Text] A delegation from Guizhou Province recently visited departments, commissions, offices, banks, and companies in Beijing. Together with leaders from these departments, they discussed and planned electric power development in the Eighth and Ninth 5-Year Plans and the construction that is to begin next year.

The Ministry of Energy Minister Huang Yichang [7806 3015 6134] maintains that, with the water and coal mine resources, Guizhou Province should not only provide for itself, but also for neighboring provinces. Guizhou should become a real energy base. The recent meeting between the Guizhou provincial government and relevant departments of the state was conducted along this line.

After repeated discussion, it was decided that Guizhou will construct, continue the construction, or remodel the following electric power projects in the next decade. Thermal electric power plants include the first phase of Aushun plant, the Feitian power plant, the Guiyang power plant, the Duyun power plant, the Kaili power plant, and the Panxian power plant. The total capacity will be 1.60 million kW. Funding for the first phase new construction of the Aushun power plant has been arranged. The down-sizing remodeling of the Guiyang power plant is scheduled for construction preparation in 1992. Based on the policy of simultaneous development for hydroelectric and thermal electric power, Guizhou is also scheduled to begin construction of the Hongjiadu and Goupitan power plants. These two large hydroelectric power plants will have a combined capacity of 2.45 million kW. The Hongjiadu project is expected to enter the construction preparation phase in 1992 or 1993, after the investment peak period for the Dongfeng power plant. The Goupitan project is slated for the Ninth 5-Year Plan period. In terms of power grid construction, it was decided that a 500 kV transmission circuit will be built from the Longtan station on Hongshui He toward central Guizhou. This will be the second channel for Guizhou to feed power to southern China, after the 500 kV transmission line for electric power development in Guizhou in the next 10 years has been clearly mapped out. Today, the capacity of the Guizhou power grid is 2.025 million kW, with an additional 1.2 million kW under construction. After the next 10 years, the capacity will increase many fold.

Outlook for Hydropower Projects in 1992

926B0069A Beijing SHUILI FADIAN [WATER POWER] in Chinese 12 Feb 92 pp 3-4

[Article by Zhu Erming [2612 1422 2494], director, Water Conservancy and Hydropower Planning and Design Academy: "Outlook for Early Stage Water Conservancy and Hydropower Work in 1992"]

[Excerpts] [Passage omitted] In the hydropower realm, in 1991 large, medium, and small hydropower stations with an installed capacity of 1.22 million kilowatts came on stream, and medium and small rural hydropower power stations with an installed capacity of 1.05 million kW were added. In addition, the state approved construction of a number of large and medium size hydropower stations including the Ertan, Tianshengqiao-1, Daxia, and Taipingyi stations. These stations are to produce more than 5 million kW of electric power. As of the end of 1991, large and medium size hydropower stations under construction nationwide will eventually produce 19.93 million kW; 10 of them are stations of 1 million kW or more. [passage omitted]

The main tasks in 1992 are as follows:

[Passage omitted] In the hydropower realm, the focus during 1992 will be on strict attention to preliminary design work for projects on which work is to begin during the Eighth 5-Year Plan. For projects for which preliminary designs have been completed, supplementary design optimization work will continue on the principle of good economic sense and improved returns. For projects on which work is to begin during the Ninth 5-Year Plan, feasibility studies are to be tendered as soon as possible. Early stage work on large and medium size hydropower projects for which local governments and departments are to raise funds should be scheduled as a priority matter. Of the 46 water conservancy and hydropower survey and design projects scheduled for 1992, 15 are being planned and plans are complete for five. Feasibility studies have been done on 15 totaling 29.95 million kW, and plans have been completed on four totaling 2.78 million kW. Preliminary design work has been done on 17 totaling 31.19 million kW, and planning has been completed on eight totaling 3.53 million kW. The main projects being planned are: the Heishanxia river section plan, the Jinping Dahe bend plan, the Jinsha Jiang (Shigu-Dukou) plan, the flow plan for the Suichuan Jiang in Jiangxi, review of the Ou Jiang plan for Zhejiang, review of the plan for the Ou He Basin in Hunan, and the Hainan hydropower plan. The main projects for which feasibility studies have been done are the Xiangjiaba and the Xiluodu on the Jinsha Jiang, the Tongzilin hydropower station on the Yaxi Jiang, the first phase of the second stage of Jinping, the Nuozhadu hydropower station on the Lancang Jiang, the Sanban Creek hydropower station in Guizhou, the Anfengqiao hydropower station in Fujian, the Wulong Shan storage-power station in Zhejiang, the Baozishi hydropower station in Jiangxi, and the Xilongchi pumped-storage station in Shanxi. The main preliminarily designed projects are as follows: The key water conservancy project in the Three Gorges of the Chang Jiang, the Pubugou and the Yaoheba hydropower stations in Sichuan, the Xiaowan and the Dachaoshan hydropower stations in Yunnan, the Silin and Goupitan hydropower stations in Guizhou, and the second phase of the second stage of the Tianshengqiao in Guizhou; the Laxiwa, Gongboxia, and Jishixia hydropower stations in Qinghai, the Xunyang and the second stage of the Shichuan hydropower stations in Shaanxi, the Lingjintan hydropower station in Hunan, the Gudongkou hydropower station in Hubei, and the second phase of the Guangzhou pumped-storage power station. The main projects for which design tenders have been invited are: the Longtan hydropower station on the Hongshui He, the Tianhuangping pumped-storage power station in Zhejiang, the Lianhua Shui power station in Heilongjiang, and the Xiaolangde and Wanjiazhai key water conservancy projects on the Huang He.

While doing early stage work, all institutes must further study the technical design, the design for invited tenders, construction drawing designs, and on-site design work for projects under construction. Electric power generation nationwide is to reach 710 billion kWh in 1992; and large and medium size electric power generating units generating 10 million kW are to go into production of which large and medium power generating units will generate 2.07 million kW. Medium and small hydropower stations going into production will also have an installed capacity of more than 1 million kW. Thus, a good job on design work for projects under construction is also a very important task. Design units responsible for project monitoring must diligently monitor projects for safety and problem-free construction.

The feasibility study for the Three Gorges project in the Chang Jiang that has attracted world attention has been examined and approved by the examination committee. The State Council is about to examine the study and prepare a report for the CPC Central Committee and the NPC requesting that the NPC discuss construction. The Standing Committee has to devote attention to preliminary design work for the Three Gorges project so as to be fully prepared for its early construction. [passage omitted]

Xinjiang Accelerates Medium, Small-Scale Hydropower Construction

926B0075A Urumqi XINJIANG RIBAO in Chinese 19 Feb 92 p 1

[Article by Correspondent Yu Qiangfu [2456 1730 1381]: "Xinjiang Accelerates Construction of Medium and Small Hydropower Construction. Reforms Investment Channels for an Increase in Sources of Funds"]

[Text] Urumqi Dispatch: Xinjiang has reformed investment channels for raising money for medium and small hydropower construction, thereby increasing sources of funds and accelerating construction making a special contribution to vigorous development of the economy at the county level.

Xinjiang is a vast region in which oases are scattered here and there among the "three mountains and two basins" making large power grid coverage difficult. Consequently, every jurisdiction in the region uses the extremely abundant and fairly evenly spread water power resources for the vigorous development of medium and small-scale hydropower, gradually building electric power facilities in which medium and small hydropower is paramount and thermal power is supplementary.

During the Seventh 5-Year Plan, authorities in the region used summarization of the lessons of previous experience in reforming investment channels. They changed from gratis appropriation of funds to discounted loans, and from mostly state investment to mostly self-reliance, raising capital through multiple channels. Thus, they increased sources of funds, improved results from the use of funds, and expanded the scale of construction. At the same time, every jurisdiction's sense of responsibility about managing and using hydropower well was increased. Authorities concerned in the region also made the building of medium and small-scale hydropower an effective means for assisting peasants and herdsmen escape poverty to become prosperous, and for vigorous development of the county-level economy. Investment was tilted in favor of the three prefectures and autonomous prefectures in the southern part of the Xinjiang. Between 1986 and 1990, half of all the installed capacity of the entire autonomous region was installed in these three prefectures and autonomous prefectures.

Statistics show that during the Seventh 5-Year Plan, the region added 137,000 kW of medium and small-scale hydropower installed capacity, up 73.4 percent from the Sixth 5-Year Plan. Installed medium and small-scale hydropower capacity totals 450,000 kW, 43.8 percent more than in the Sixth 5-Year Plan. In 1990, medium and small-scale hydropower generated 1.42 billion kWh of electricity, 1.12 billion kWh of it coming from small hydropower. Eighty percent of counties (or cities), 70 percent of townships, 77 percent of villages, and 60 percent of peasants and herdsmen in the region use hydropower.

Dashankou To Generate Power in 1992

926B0058A Urumqi XINJIANG RIBAO in Chinese 24 Dec 91 p 1

[Article by Wang Xuelin [3769 1331 2651] reporting from Korla]

[Text] 17:45 on 12 December marked the successful filling of the lower gate of the Dashankou power station. The No. 1 generator will produce power for the grid within a year.

Dashankou power station is a priority project in the Seventh 5-Year Plan and is the largest hydroelectric station in the Xinjiang Autonomous Region. It is also the only microcomputer-controlled hydroelectric station in Xinjiang. It has a total capacity of 80,000 kilowatts and an annual output of 310 million kWh. The construction of the station, begun in 1985, has been very difficult in the last 6 years. The main dam, hydroelectric opening, main and auxiliary plant building, and the switching station have basically been completed. After the station is built, the severe power shortage in the Bayingolin Mongol Autonomous Prefecture will be greatly alleviated, and the station will also provide ample power for large-scale oil exploration activity in the Tarim Basin.

The reservoir capacity of the Dashankou station is 28.8 million cubic meters, the modulation reservoir has a capacity of 45.5 million cubic meters, the normal water level is 1,406 meters, and the design waterhead is 51 meters. The reservoir has been filled for about 1 week and the No. 1 turbine generator is ready for a test run.

Puding Update

926B0058B Guiyang GUIZHOU RIBAO, 13 Dec 91 p 1

[Article by Jiang Xingqian [5592 5281 7816]

[Text] The 75-meter-high dam of Puding hydroelectric power station, a key science and technology project of the Eighth 5-Year Plan, will be an arch gravity dam built of rolled concrete. The pouring of concrete officially began on 23 November. The dam uses an integrated thin layer pouring method. The new rolling technology continuously builds up the height. This 75,000 kW power station was built by the Wujiang branch of the 8th hydroelectric power bureau. The first generator will begin producing electricity in 1992.

Jilin Adds Record Amount of Thermal Power in 1991

926B0058C Changchun JILIN RIBAO in Chinese 12 Jan 92 p 1

[Article by He Rufei [0149 1172 7378] and Xue Li [6043 7787]]

[Text] In 1991, Jilin built a 500,000 kW thermal power plant and added a 200,000 kW generator into the power grid. This set a record for the amount of thermal power added in 1 year. It was also a year with the most electric power development under local funding.

From 1985 to 1991, Jilin has raised 1.1 billion yuan for developing electric power and jointly funded with the state the construction of 1.5 million kW of thermal power. A large-scale power plant, the Xuangliao power plant, is under construction. This plant has a total capacity of 2.4 million kW and is jointly funded by Jilin and the state, with Jilin responsible for 60 percent of the investment.

In order to speed up the pace for electric power development, Jilin also raises local money for power construction. One example is the 200,000 kW generator of the Zejiang power plant. This generator passed the 72-hour test run on 30 December 1991 and joined the grid.

While speeding up the construction of thermal electric power, Jilin is also working on power transmission and transforming facilities. In the last 6 years, Jilin has built 16 transmission lines of 220 kV or higher. The total length is 1,281 kilometers. Newly built are 17 substations of 220 kV level, and 2.34 million kVA have been added to the transforming capacity.

Infrastructure for Dalad Plant Project in Place

926B0074A Hohhot NEIMENGGU RIBAO in Chinese 31 Jan 92 p 1

[Article by Wang Zepu [3769 3419 2528]: "Preparatory Work Completed for Construction To Begin on Dalad Power Plant Project"]

[Text] Dispatch from Dongsheng. Thanks to the efforts of units and agencies concerned, and the urgent earlier work of the power plant's staff members and workers, preparations are now complete for construction to begin on the Dalad Electric Power Plant project in Inner Mongolia. Main facilities fully meet requirements for beginning work.

The Dalad Power Plant scheme has a capacity of 5 million kilowatts, 1.32 million kW in the first phase, with plans calling for the follow-on construction of four 330,000 kW power generation units. Two of the units are to go into operation during the Eighth 5-Year Plan. The Dalad Power Plant preparatory team was formally founded in December 1990, and in August 1991, the Dalad Power Plant was formally inaugurated. The preparatory team and the staff members and workers of the power plant carried forward a spirit of arduous struggle, working on the site as they planned its construction. The Inner Mongolian Management Bureau and the Dalad Power Plant conscientiously put into effect new regulations and controls from the Ministry of Energy Resources and the autonomous region for the new plant, generating a stream of guidance. They accelerated the pace of early stage work with a view to beginning construction in 1992 and putting one power generation unit into operation in 1992 and another in 1994. By the end of 1991, they had requisitioned the land, razed or removed structures from it, and put all of the infrastructure in place, and they began construction of some offices and living accommodations as well. They built five roads totaling more than 3,300 meters in length, sank seven wells producing 350 tons of water an hour, built two 300 cubic meter reservoirs, erected six power lines, leveled 12,800 cubic meters of land at the construction sight, and hauled away 24,000 cubic meters of earth to set the stage for the formal beginning of work on the project.

Wujing Thermal Power Plant's First Unit Goes Into Operation

926B0074B Shanghai JIEFANG RIBAO in Chinese 25 Feb 92 p 1

[Article by Trainee Liu Liang [0491 0081] and Correspondent Zhang Zhiyuan [1728 5268 6678]: "China's First Critical Large Model Thermal Power Equipment, the Wujing Project's 300,000 Kilowatt Generating Unit, Begins To Generate Electricity. Shanghai Area-Manufactured Equipment Accounts for 77 Percent of Value of All Equipment Used"]

[Text] China's first large critical thermal power equipment having a technology at the international level of the 1980's—the Shanghai Wujing project's first 300,000 kw generating unit—was handed over yesterday to begin power generation following trial runs as the construction project required. This demonstrates that China is ready to compete in international markets in the design, manufacture, and installation of large power plants.

The Wujing Thermal Power Plant, which is located along the Huangpu Jiang in suburban Shanghai, is one of the city's principal power plants. In accordance with world practice, tenders were called for and bids submitted internationally for this newly built two 300,000 kW generating unit plant. A consortium made up of the Shanghai Allied Electric Power Corporation, the Shanghai Electric Power Construction Bureau, and the Northwest Electric Power Design Institute won the bid, opening the way for China's large electric power manufacturing industry to enter the international competition arena.

Requirements for manufacture of equipment and construction of the Wujing project are very high. The project contract provides for a "single responsibility system," which means that only a small number of countries in the world have the ability to design, manufacture the equipment, construct the plant and install the equipment, test the entire plant, and manage all particulars. In undertaking to build such a sophisticated power plant for the first time, China took numerous risks. In order to ensure high quality and high standards in building the project, the World Bank inspected the project twice each year. Staff members and workers of the Shanghai Allied Electric Power Corporation, the Shanghai Electric Power Construction Bureau, and the Northwest Electric Power Design Institute exhibited a spirit of unity, cooperation, and arduous struggle, pulling together as a team in designing and manufacturing the equipment, building the plant, and installing the equipment. After digesting the design principles of the American Yibasiku [phonetic] Corporation, the Northwest Electric Power Design Institute began painstaking design work. In accordance with international practice, the Shanghai Electric Power Construction Bureau provided coordination and control throughout the entire construction process, waging a very able battle to ensure the building of a large power station meeting world standards. The owners of the enterprise, the Shanghai Municipal Electric Power Industrial Bureau and the Wujing Thermal Power Plant strictly supervised contract fulfillment, and effectively organized operational control to ensure that the generating units would go into operation without a hitch.

Equipment manufactured in the Shanghai area accounted for 77 percent of the value of all equipment manufactured for the Wujing project. Seventeen key pieces of equipment for the main and ancillary generators were imported from abroad, and the patented skills of world-renowned manufacturing plants were digested and assimilated. After several years of major industrial battles and scientific and technical feats, China was able to manufacture the units itself. The turbines, generators, and boilers for the three main units were manufactured by the Shanghai Turbine Plant, the Shanghai Electrical Machinery Plant, and the Shanghai Boiler Plant, 93 percent of all the equipment being manufactured in China. For the automated control system, a monitoring and control system employing advanced modern decentralized microcomputers was used. The first generating units were manufactured entirely in accordance with quality standards and subjected to a rigorous quality guarantee system. Testing preliminary to acceptance was employed in the construction and installation of 2,598 items, 97 percent of which were found to be sound. The technical performance and the efficiency standards for all of the generating units exceed those of other domestically produced 300,000 kW generating units of the same kind.

The Wujing project is the largest thermal power construction project that China has ever contracted independently using World Bank loans, the project contract totaling $168,900,000 in value. This sets the stage for the Shanghai Allied Electric Power Corporation to enter the work market for building electric power stations. Today, following more than 3 years of efforts on the part of the builders, because of the premium quality and the on-time completion of the Wujing project's first power generating unit beside the Huangpu Jiang, the plant is hailed as a Shanghai "showcase" meeting international standards that has attracted the interest of others in the same industry both at home and abroad. World Bank officials also consider this a successful example of the use of World Bank loans by a developing country.

At the present time, the second power generating unit of the Wujing project is being feverishly built. Plans call for it to begin generating electricity in September 1992. This will play a major role in further easing the shortage of electricity in Shanghai.

Problems in Using Gangue as Power Plant Fuel Discussed

926B0056A Beijing ZHONGGUO NENGYUAN [ENERGY OF CHINA] in Chinese No 11 Nov 91 pp 17-20

[Article by Fan Kai [2868 0418] of Kunming Designs Institute for Non-Ferrous Metals: "Problems in Using Gangue as Power Plant Fuel Discussed"]

[Text] Gangue has been used as a power plant fuel in China for more than a dozen years. In order to conserve energy, the government always encourages power plants to use gangue, especially tailings of coal washing plants, as a fuel. A policy was drawn up to favor the construction of gangue-burning power plants. Since the mid 1970's, many such power plants have been put into operation. After years of experimental operation, we have accumulated considerable experience and uncovered a number of problems. We are at a stage to promote the widespread use of gangue-burning power plants.

I. Status of Using Gangue as Power Plant Fuel

Based on the 1983 economic yearbook, it was estimated that gangue-burning power plants would generate 600 million kWh of electricity in China in 1988. On the average, 600 grams of coal is consumed to generate a kWh of electricity. This is equivalent to a saving of 360,000 tons of standard coal per year. If the amount of heat produced by gangue (at the base) is 8373.6 kJ/kg (2000 kcal/kg), it is equivalent to 1.26 million tons of gangue. According to available statistics, we had over 30 million tons of gangue, i.e. 20 percent of the raw coal produced in coal mines under the centralized dispatch system alone, in 1988. This is much more than is being used for power generation. It is an indication that there is still considerable work to accomplish before comprehensive utilization of gangue is a reality. As the economy grows, the coal industry is paying more attention to coal selection and washing to improve product quality. There will be more byproducts, such as washed medium grade coal and gangue, as the coal washing capacity increases. In addition, there is a considerable amount of low grade coal which cannot be washed and used in any applications. Therefore, it is an important aspect of our energy conservation program to find uses for such low heat content fuels.

As far as gangue is concerned, the Ministry of Coal Industry planned to construct 45 new gangue-burning power plants in the Seventh 5-Year Plan with a total capacity of 1 million kW. However, only 300,000 kW was completed at the end of the Seventh 5-Year Plan. Of course, lack of funding is only one of the problems. More importantly, there are still some problems associated with the gangue-burning power plant. The policy is also less than perfect. Various local authorities implemented the policy differently. These factors also adversely affected the development of gangue-burning power plants.

II. Problems Associated With Gangue-Burning Power Plants

Using gangue to generate electricity is a new application in China. If it is not economically attractive, it will not be competitive to be promoted for widespread use. Various problems associated with such plants today are essentially related to the economic benefits.

(I) The annual number of hours of operation is usually not very high.

The furnace in our gangue-burning power plant is a boiling fluidized-bed furnace. The advantage is that it is adaptive to a variety of coal, including low heat content coal. The disadvantages include: thermal efficiency is low, only 67-72 percent, poor coal-burning stability and difficulty in operation. Based on our understanding, the average operating hours of this type of furnace is 4000-5000 hours per year. Some individual power plants have a lower number. Since there are no spare furnaces, the power plants could not operate for a large number of hours per year. It is quite less than the 6000 hours specified by the Ministry of Coal Industry. The primary causes for this situation are:

1. The heat content of gangue is too low for the furnace.

It is well recognized that a boiling fluidized-bed furnace can burn low heat content coal. However, there is some controversy about what the optimum heat content should be. Our furnace is designed for 6280.2 - 8373.6 kJ/kg (1500 - 2000 kcal/kg) based on the heat content of washed gangue which is usually between 4186.8 - 8373.6 kJ/kg. Some are higher than this range. It is dependent upon the type and quality of the raw coal and the recovery rate. In reality, the heat content of washed gangue fluctuates widely. Washed gangue is the primary fuel for a gangue-burning power plant. In some plants, the fluidized-bed furnaces were designed to match with heat content of the gangue produced locally at the time. However, the furnaces face the problem of unstable combustion after they were put in operation. As far as the fuel is concerned, in addition to the heat content, other factors, such as volatile components, specific gravity and ash content, also affect the stability of combustion. Presently, many furnace makers cannot design different furnaces for individual users based on local requirements. A furnace is designed based on the gangue produced somewhere and this model is being distributed to other places as a product. Hence, if the heat content of the gangue is too low, there will be numerous adverse factors to allow the furnaces to operate stably over long periods of time. After years of operation, the conclusion is that stable combustion can be ensured when the heat content of the fuel is above 10467 kJ/kg (2500 kcal/kg).

2. Most problems are related to crushing and dehydration of washed gangue.

The boiling fluidized-bed furnace has very stringent requirements on fuel particle size and water content. The appropriate particle size should be in the range of 1-8 mm. Particles less than 0.5 mm are usually not used. The water content should be less than 7 percent. The usual water content from ordinary gangue plants is as high as 12-16 percent and the particle size is less than 50 mm. Therefore, crushing and dehydration are required. Because the physical properties of washed gangue vary from place to place, it is very difficult for power plants to prepare the coal to burn. For example, a gangue-burning power plant in Yunnan was designed to crush the gangue first and then to remove the water by natural dehydration in a cylindrical container. In reality, the operation is problematic. The main problem is that the particle size varies widely. Usually, approximately 5 percent of the crushed gangue is below 0.5 mm in particle size. Nevertheless, more than 20 percent of the crushed gangue there is less than 0.5 mm. The power plant made some adjustment to the fuel by mixing in a substantial amount of low grade coal into the gangue. This situation was improved somewhat. However, the gangue utilization rate is still far below the target value in the design.

3. The wear and tear is high for boiling fluidized-bed furnace which leads to a high level of maintenance.

Since washed gangue is the fuel for these furnaces, the ash content is as high as 50-70 percent. The pipes, refractory brick and coal saver in the furnace are suffering from serious erosion. Furnaces need frequent repairs and maintenance.

4. The power plant management level is relatively low.

Because gangue-burning power plants are power plants owned and operated by the coal industry, they are not subject to the supervision of the power system. Consequently, they do not rigorously obey the rules and standards set by the power system. Compared to conventional power plants, gangue-burning power plants have the following disadvantages:

(1) There is a shortage of trained personnel in thermal engineering, power generation and power distribution.

(2) Workers are less qualified.

(3) There is a lack of power plant management experience.

These reasons also directly affect the annual operating hours of gangue-burning power plants. The low operating hours resulted in less power generated. The profit is low and the return of investment is not attractive.

(II) Scale of Gangue-Burning Power Plants and Grid Integration

The evaporation rate of our boiling furnace is somewhere in the range of 10-130 t/h. Most of them are at 35 t/h. They are matched with 6,000 kW steam turbine generators. Most gangue-burning power plants use 6,000 kW generator units. It is also the more mature type. The total capacity of such a power plant may be 2 x 6,000 kW, 3 x 6,000 kW and 4 x 6,000 kW, depending upon the water supply, power load and gangue production rate of the coal mine.

1. Determination of gangue quality and quantity.

The quality and quantity of gangue directly affect the scale and constraints of the power plant. Factors such as heat content, volatility, ash content, particle size distribution and specific gravity determine how useful the gangue is. This requires detailed analysis of coal quality. Physicochemical data needs to be collected over long periods of time as a function of heat content fluctuation and this information must be made available to the design department to serve as a basis for demonstrating the feasibility of a gangue-burning power plant. However, this factor was not taken seriously by some coal mines. The data provided is incomplete and inaccurate. Their thought is that they have no resources to blend in raw coal if there is not enough gangue to burn. If the gangue quality is inadequate, they can blend in high grade coal. This is caused by the external factor that our policy overly stresses the use of gangue and neglects the facts that in some areas the quality of gangue is too poor to burn as a fuel for a power plant with fluidized-bed furnaces. There is a lack of rigorous review before the power plant is being constructed and a lack of effective supervision after it is put into production. In some cases, the data provided is drastically different from reality. The only solution is to blend in a great deal of coal. Because the fuel being used is quite different from that in the origin design, the process structure and equipment selection become less than optimal.

2. Grid Integration

Because we are still divided by different systems, there are contradictions which are difficult to resolve. Although the government has ordered that gangue-burning power plants can be integrated into the national power grid. If excess power is delivered into the power grid, the electric power department should only charge the cost and return the profit to the coal mine. In addition, a gangue-burning power plant can exchange electricity with the power grid and the accounting is done on a monthly basis. In reality, this policy is very difficult to implement. In some areas, it is not followed. For example, it cost approximately 0.072 yuan/kWh to generate electricity at a gangue-burning power plant in Yunnan in 1990. It only received 0.052 yuan/kWh when delivering power to the grid while it had to pay 0.122 yuan/kWh to buy power from the grid. In other words, it could not sell power to the grid at cost and could not offset the power purchased from the grid on a monthly basis. The electricity department has its view of the reasons for this. (1) Gangue-burning power plants are usually low in capacity. After supplying power to the coal mine itself, there is not much power left for the power grid. The supply is not very stable. The electric power department is unwilling to accept this kind of power. (2) Due to load fluctuation, it is very often that the peak load of the power grid coincides with the peak load at the coal mine and vice versa. Especially in view of the fact that the government has not changed the pricing structure to differentiate consumption during peak and off-peak hours, the electric power department has a hard time accepting this kind of power swap. Based on our understanding, gangue-burning power plants are delivering power to the power grid during off-peak hours. Often, it delivers ¼ of its annual capacity. The more power it delivers to the power grid, the more money it loses. Based on the above reasons, some coal mines in coal producing areas wish to establish their own power transmission systems. Since there is a national power grid already, it would be wasteful to build another power grid. Furthermore, without the cooperation of the electric power department, it would also be very difficult to accomplish.

(III) Economic Evaluation of Gangue-Burning Power Plant

If a gangue-burning power plant operates normally, because it costs nothing to use washed gangue, the cost to generate electricity is lower than other power plants. It does have significant economic advantage. Nevertheless, over the years, coal price does not reflect its cost. Most coal mines are losing money due to policy related reasons. Despite subsidies from the government, the losses are still substantial. Since the gangue-burning power plant belongs to the coal mine, its economic benefit is directly affected. Some gangue-burning power plants do not keep independent accounting records. In order to reduce their losses, some coal mines are using the power at a low rate to switch the profits to coal production. These power plants actually showed very little profit. Some of them even showed losses. Hence, the loans cannot be paid back. Some coal mines are delaying their payments back on the construction loan. Once the reputation is ruined, it is very difficult for new power plant construction loans to get approved.

III. Outlook of Gangue-Burning Power Plants and Measures for Improvement

In recent years, a circulating fluidized-bed furnace has been developed. This furnace was developed to solve problems related to the boiling furnace, such as low thermal efficiency and high ash content. The special feature is that the chamber of the furnace is higher than that of the boiling furnace to allow the fuel to burn to completion over a longer period of time. In addition, an ash collector, i.e. a vortex separator, is also included. The ash gathered by the vortex separator is sent back down to the fluidized-bed to continue the burning process. Thus, the chemical energy loss due to incomplete combustion is minimized and the ash content in the smoke is also reduced. This arrangement improves the furnace efficiency and provides better protection to the environment. The thermal efficiency has reached as high as 86-89 percent. This furnace is in field trial now at a few sites. The furnace is designed to burn soft coal and low-grade coal. Based on the performance so far, the heat content of the fuel used is above 14,653.8 kJ/kg (3,500 kcal/kg). The actual furnace efficiency is dependent upon the combustion process. It usually ranges between 76-89 percent. Since it is still in field trial, the operation is not very smooth yet. Therefore, there are still problems in directly using gangue to fuel a circulating fluidized-bed furnace.

Based on the situation in other countries, considerable progress has been made in boiling furnace and circulating fluidized-bed furnace, particularly in areas such as high capacity and high thermal efficiency. The development of fluidized-bed furnace abroad is focused on burning high sulfur coal. Due to industrialization, environmental pollution is becoming a serious issue. The mounting quantity of sulfur dioxide discharged causes every place to suffer from acid rain to some extent. To this end, most industrialized nations have stringent standards controlling the discharge of harmful substances into the environment. As far as smoke from furnaces is concerned, ash content, sulfur dioxide and NO_x are the main items subject to such control. Since it is very convenient to put limestone directly into a boiling furnace or circulating fluidized-bed furnace for in-situ desulfurization without much added cost, it is becoming very popular. Based on information on hand, the boiling furnace and fluidized-bed furnace have been commercialized. However, the heat content of the fuel used abroad is much higher, usually above 16,747.2 kJ/kg (4,000 kcal/kg), than what we are using in our boiling furnaces.

The worldwide trend is to develop circulating fluidized-bed furnaces. This is being scaled up. Based on our understanding, the development of a 220 t/h circulating fluidized-bed furnace has been included as a national focal technical project this year. The fuel for a circulating fluidized-bed furnace is primarily low-grade coal. Its development brings a bright prospect for the low-grade coal available. On the other hand, how to make full use of gangue is also a pressing issue. Based on where we are, there is considerable experience and advantage to burn gangue in conventional boiling furnaces. A series of measures should be taken to solve the problems related to the use of gangue for power generation.

1. All studies on boiling furnace or circulating fluidized-bed furnace, in addition to addressing thermal efficiency and environmental pollution concerns, should investigate the adaptivity of the furnace to low heat content fuel. Burning gangue is already a form of recycling waste. The thermal efficiency of the furnace cannot be very high. Key issues to be addressed in the near future to perfect the operation of gangue-burning power plants are to find ways to maintain stable combustion and to reduce erosion by optimizing furnace material and structure. Manufacturers should design furnaces based on the composition of the gangue to be used.

2. The coal system should establish a dedicated organization to conduct a nationwide survey on the species, quality and quantity of gangue available. Every coal mines should cooperate to provide analysis result of the

gangue it produces. An accurate assessment should be made based on the actual data gathered to determine whether an area is suitable for the construction of a gangue-burning power plant. Furthermore, gangue-burning power plants already in operation should be monitored for quality and profitability. In the near term, gangue with higher heat content should be given priority. It is more desirable to have a heat content of over 8,373.6 kJ/kg (2,000 kcal/kg).

3. In the design of gangue-burning power plant, serious consideration should be given to match the furnace with the steam turbine generator. The number of annual operating hours is usually relatively low, approximately 5,000 hours. However, a steam turbine generator typically can operate over 7,200 hours a year. The idle time is too long. If a spare furnace is included in the design, then the situation can change drastically. Let us use a 2 x 6,000 kW power plant as an example. The original design is two furnaces and two generators. Every year the number of power generating hours is 2 x 5,000, or 10,000 hours. If an additional furnace is added, i.e. three furnaces and two generators, the number of power generating hours can be increased to 15,000 hours. To add another furnace, including the plant space it requires, only increases the investment by approximately 10 percent. However, the power generating capacity can reach 3 x 6,000 kW. The economic benefit is apparent.

4. It is necessary to clearly identify that a gangue-burning power plant is a fiscally independent entity during the approval process. The power plant supplies electricity to the coal mine at a slightly lower price compared to what the coal mine pays for electricity from the power grid in order to allow the gangue-burning power plant to make a reasonable profit. The construction loan should be paid off within 5 years, definitely no more than 10 years. We have to stress the significance of economics and work hard to raise the number of operating hours per year. With the assurance that the furnace is operating normally, we should use as much gangue as possible to reduce costs and enhance competitiveness. This is the key to solving the problem with the electric power grid system.

5. The coal system should be open and allow the electric power department to participate in the management of gangue-burning power plants. The electric power department has a complete set of management standards concerning thermal power plants. Gangue-burning power plants should be rigorously managed according to the standards set by the electric power department whenever possible. Furthermore, we must attract talented people because this is an effective way to improve the management level of such power plants.

Sino-Japanese Cooperative Prospecting Venture in Tarim Basin

926B0075B Urumqi XINJIANG RIBAO in Chinese 19 Feb 92 p 1

[Article by Reporter Sun Bin [1327 2430]: "Sino-Japanese Tarim Basin Prospecting Project Moves Along Smoothly. First Shipment of Equipment From Japan Reaches Urumqi"]

[Text] Urumqi Dispatch: The geological and global physics prospecting project underway in the Kashi-Yecheng area of the Tarim Basin in Xinjiang in which the State Council is directly interested, which was jointly contracted by the Joint Team of the Geology Survey Department of the Xinjiang Petroleum Bureau with the China Petroleum and Natural Gas Corporation and the Japan Petroleum Consortium, and in which Japan invested 8 billion yen recently entered the substantive stage of cooperative implementation with the arrival in Urumqi of the first shipment of production equipment from Japan.

This project got underway following the signing in Beijing on 5 July of the "Basic Agreement on a Petroleum Geology and Geophysical Survey in the Kashi-Yecheng Region of the Tarim Basin in China" between the general manager of the China Petroleum and Natural Gas Corporation, Wang Shou [3769 1108], and the Japan Petroleum Consortium. The survey is being conducted by the Joint Team of the Geology Survey Department of the Xinjiang Petroleum Bureau. In conscientious implementation of this agreement, the Chinese and Japanese personnel engaged in the project personally went to the Kashi-Yecheng region to conduct an on-site survey to find out in detail about transportation, medical services, the climate, the selection of a base, and the availability of water for production and daily life when construction begins. They made a detailed survey of the region's terrain and topography, and took samples from rock outcroppings.

While conducting the survey, the personnel from both sides spent the past half year on full discussions about the administrative and technical aspects of the cooperative prospecting venture as spelled out in the agreement. They also did preliminary planning on equipment, personnel, expenses, transportation, and seismic wave measurements, and reached agreement about a preliminary geological assessment of the area, the geological goals of the survey, as well as some of the problems that might be encountered in the survey and means of solving them. Formation of the team has now been completed, and the operating stage is at hand.

Will Inland Oil Fields Open Up to Foreign Developers?

40100032 Beijing CHINA DAILY (Business Weekly) in English 4 Apr 92 p 1

[Article by Chang Weimin]

[Text] China is believed to be considering whether to open up its inland as well as offshore oilfields to foreign firms.

Officials from these firms told Business Weekly that they are eager to help develop oil-bearing areas in basins in the Xinjiang Uygur Autonomous Region, where oil reserves are so large that they are expected to become the country's main supply base.

It was confirmed last week that the continental shelf, with water no deeper than 5 meters, is likely to be opened up to foreign oil companies for exploration.

Also likely to be thrown open is the East China Sea, where rich oil and gas resources are expected to be discovered, to add substantially to the country's confirmed reserves.

A lot of foreign equipment has been used in the Tarim, Turpan-Hami and Junggar basins in Xinjiang, where huge reserves of oil have been confirmed, but no foreign firms have, so far, been promised access to petroleum development there.

A Shell manager has said: "We want to enter Tarim," and analysts say foreign oil firms' expectations have risen following Deng Xiaoping's tour of South China early this year, when he reportedly urged bolder steps to accelerate reforms and opening up to the outside world.

China opened the South China Sea to foreign oil firms in 1982 and since then at least $3.13 billion of foreign investment has been used there. Both Chinese and foreign firms have made money.

China also opened some areas in 11 provinces in the south and now three contracts on cooperation with foreign firms are being implemented.

However, Roger Abel, president of the Society of Petroleum Engineering, a high-profile international organization based in the United States, says foreign firms' activities in inland areas are limited.

There would be benefits both for China and its partners if it opened up the areas where there are known to be enormous oil and gas reserves, Abel said.

China National Petroleum Corporation has already started preparations so that it can go into action quickly as soon as the government's decision on opening the continental shelf is announced.

Asked about the possibility of opening the three basins in Xinjiang to foreign oil firms, a CNPC official said that China would not be likely to take such a bold step at present.

The China National Offshore Oil Corporation now has more than 40 contracts on cooperation with foreign firms in hand and expects to sign another eight this year.

On March 22, the day before the fourth international meeting on petroleum engineering, and the international petroleum technology and equipment exhibition opened in Beijing, the Society of Petroleum Engineering established its first Chinese section in the city.

New Round of Petroleum Industry Contracting

926B0061A Hefei ANHUI RIBAO in Chinese 20 Jan 92 p 3

[Article by Zhu Youdi [2612 1635 2769] and Zhang Chaowen [1728 6389 2429]: "China's Petroleum Industry Enters New Round of Contracting. Zhu Rongji [2612 3579 1015] Conveys Warm Regards to the Petroleum Front Line on Behalf of Premier Li Peng"]

[Excerpts] Xinhua She, 18 January. Deputy Premier Zhu Rongji met delegates to the All-China Petroleum Industry Bureau's Conference of Leading Plant Cadres at Zhongnanhai this afternoon. In a speech, he affirmed the accomplishments made in the country's petroleum industry during the past year, and conveyed the warm regards of Premier Li Peng to the broad masses of cadres, scientific and technical personnel, and working comrades on the petroleum front line.

Guided by the CPC Central Committee's and State Council's strategic plan for "steadying the east and developing the west," oil and gas production in the nation's petroleum industry nationwide has seen consistent increase since 1991. In 1991, the country produced 139.76 million tons of crude oil and 15.4 billion cubic meters of natural gas in the initial achievement of balanced and consistent output according to plan, a situation unprecedented in recent years. The country's 20 on- shore oil fields either fulfilled or overfulfilled production plans. Oil exploration also improved. Gas prospecting was steadily intensified and extended to new fields, some major finds being made. Both oil and gas reserves increased as the number of oil and gas fields discovered steadily expanded.

During the past 10 years, contracting by the country's petroleum industry has produced sustained and steady development. At today's conference, the director of the China Petroleum and Natural Gas Corporation, Wang Tao [3769 3447], signed a new round of contracts with leaders of 17 petroleum management bureaus and petroleum prospecting bureaus, including those at Daqing, Shengli, Liaohe, Zhongyuan, Xinjiang, North China, and Dagang. The China Petroleum and Natural Gas Corporation announced that it will deliver all pertinent state policies to on-shore oil fields, with the exception of the three major oil fields at Daqing, Shengli, and Liaohe, requiring them to carry out reforms, and become responsible for profit and loss. The leaders of these oil fields said that during the coming year they will spur the sustained, steady development of the country's petroleum industry through the intensification of reform and increased openness. [passage omitted]

In his summarization speech at the conference Wang Tao said that the main task of China's petroleum task in the future will be to move ahead from continued vocational contracting and perfection of the contract responsibility system to changing the operating mechanism, readjusting the internal structure, and smashing "iron rice bowls, iron arm chairs, and large common pots" in order to spur changes from production type to operating type petroleum enterprises. The petroleum industry has to learn to swim in the ocean of a planned commodity economy.

Director Wang Tao noted that in the new round of petroleum industry contracts, the correlation among reform, development, and stability will have to be handled diligently. We will have to depend wholeheartedly on the working class for the development of production, for increase in the value of state assets, for enterprise returns, and for staff member and worker earnings. [passage omitted]

Characteristics of Oil-Gas Pools and Hydrocarbon Distribution in the Turpan-Hami Basin

926B0062 Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 12, No 4, Dec 91 pp 351-363

[Article by Zhao Wenzhi [6392 2429 2535] and Li Wei [2621 0251] of the Beijing Petroleum Exploration and Development Scientific Research Academy Geology Institute and Yan Liecan [3601 3525 3503] of the Yumen Petroleum Management Bureau Exploration and Development Research Academy: "A Preliminary Probe Into Oil and Gas Pool Categories and Characteristics and Distributional Laws of Oil and Gas in Turpan-Hami Basin"; manuscript received 26 February 1991, revised and returned 5 April 1991]

[Text] Abstract: With a prerequisite of delineating the oil and gas pools in Turpan-Hami Basin into three basic categories of structural, stratigraphic-lithologic, and compound types, each category of oil and gas pool can be further classified according to the relationship between oil and gas in-migration and trap formation into comatured plentiful type, semi-comatured non-plentiful type, comatured but subsequently destroyed type, and non-comatured poor type oil and gas pools. The accumulation of oil and gas was subject to control by paleouplifts, paleoslopes, fracture zones, and strata erosion pinch-out belts, so they have the characteristics of compound oil and gas accumulations.

Key terms: Turpan-Hami Basin, oil and gas pool categories, oil and gas distribution laws

First author introduction: Zhao Wenzhi, male, 33 years of age, engineer (Masters'), petroleum geology and exploration

Major breakthroughs have been made since 1986 in oil and gas exploration in Turpan-Hami Basin and four large and medium-sized oil and gas fields have been discovered there which control extremely substantial petroleum geological reserves. The authors have been involved in research on the petroleum geology characteristics and oil and gas distribution laws in this basin since the end of 1986. We have discovered that many aspects of its petroleum geology characteristics were not fully understood from exploration during the 1950's and 1960's. Moreover, a new understanding of these areas has played a major role in rapid breakthroughs in oil and gas exploration in the basin. This article begins with an analysis of the unique properties of already discovered oil and gas pools and summarizes the oil and gas pool categories and characteristics of the basin, and it explores the basic laws of oil and gas accumulation and distribution based on the interrelationships of structures, sediments, and oil and gas generation, migration, and accumulation.

I. Regional Geological Background and Basic Geological Conditions

Turpan-Hami Basin is one of three large sedimentary basins within the boundaries of Xinjiang and covers an area of about 48,600 km^2. It can be divided on the basis of geological structures into large eastern and western depressions and an intermediate uplift. The western part is called the Turpan depression and covers an area of about 21,000 km^2. The eastern part is called the Hami depression and covers an area of about 15,000 km^2. The central part is called the Liaodun uplift and covers an area of 12,500 km^2. New seismic data indicates that Liaodun uplift is uplifted to the south but not to the north and that the northern part is a channel connecting the eastern and western depressions. Turpan-Hami Basin is filled with continental facies sediments from the Permian to Quaternary systems and the maximum thickness of the sediments is more than 8,700 m. The Turpan depression is primarily from the Jurassic system but the Permian and Triassic systems also developed there and they form an asymmetrical configuration that is thick in the north and thin in the south with northern faults and southern overlap. The Hami depression is primarily the Triassic and Permian systems but the Jurassic system also exists. The maximum thickness of sediments there exceeds 6,000 m.

The primary oil generating strata in Turpan-Hami Basin are the lower Jurassic system Badaowan group (J_1b) coal series, middle Jurassic system Qiktim group (J_2q), upper Permian system Tarlang group (P_2t), and middle and upper Triassic system Xiaoquangou group ($T_{2+3}xq$) deep to semi-deep lake facies mudstone. The main reservoir strata is sandstone from the same periods that lies between and alternates with these oil generating strata. It has been confirmed that the primary oil-bearing strata are the Jurassic system Xishanyao group (J_2x), Sanjianfang group (J_2s), and Qiktim group and the middle and upper Triassic system Karamay group ($T_{2+3}k$) group (Figure 1 [not reproduced]).

Local structures are extremely well-developed in Turpan-Hami Basin. Some 72 local structures have already been discovered, mainly anticlines and fault- anticlines, which account for 81.9 percent of the total number. They are distributed in clusters and belts and their development is concentrated in the basin's seven large fault-anticline zones. The generation of most of the local structures is related to the effects of shear-compression thrust faulting and the earliest were formed at the end of the Triassic. The large-scale formation occurred at the end of the Jurassic and end of the Tertiary. The formation and migration of these local structures are characterized by regularities of developing from the paleouplift toward the middle of the depression. Thus, most of the paleostructures are paleouplifts and paleoslopes in alternating positions, whereas there are mostly new structures within the depressions. The local structures often manifest characteristics like high amplitude, asymmetry of the two flanks, unconformity of the high points of deep and shallow strata, varying degrees of thickening in the central part of plastic strata, and so on. They can be classified into normal flower-shaped, reverse rotation, shear anticline, drag anticline, thrust fault anticline, short-axis anticline, and other structural types that are united within the three large structure combinations of shear, thrust faulting, and bedrock uplifting.

II. Trap Categories and Geological Conditions of Oil Formation

The traps in Turpan-Hami Basin can be divided based on the principle of integrating formation and shape into three main categories and 15 small categories (Table 1). Among them, structural trap types predominate, followed by structural-lithologic compound types and lithologic types. Most of the structural traps are anticlinal traps, and among them shear-compression anticlines and fault-anticlines hold the superior position.

One of the keys to whether or not oil and gas accumulated in the traps is the interrelationship between trap formation and the maturity and migration of the oil and gas. Of course, the position of the traps also determines the opportunity for the traps to receive oil and gas. Thus, this article uses the three concepts of comatured, semi-comatured, and non-comatured to indicate the three types of conditions of the occurrence of trap formation and oil and gas maturation and migration at the same time, slightly later, and much later to represent a series of changes from substantial to limited opportunities for the traps to receive oil and gas.

1. Comatured-type traps: This refers to trap formation that occurs simultaneously with or in advance of oil and gas maturation and large-scale discharge. In Turpan-Hami Basin, the traps in this category formed early and also have rather good paleostructure and new structure overlap conditions. Moreover, the traps are located in the primary routes of oil and gas migration. Regarding their formation, most of the traps in this category were formed during the late Jurassic or even earlier. Regarding their distribution, most are located in structural zones on a background of paleouplifts between and at the margins of oil generating depressions.

Table 1. Categories and Characteristics of Traps in Turpan-Hami Basin

Category				Primary characteristics	Examples
Main category	Basic type	Subcategory	Detailed category		
Structural traps	Anticline type	Pure compression anticlines	Integral anticlines	Linear shape, compact, high amplitude, asymmetrical	Bogda premontane anticline
			Reversed anticline	Linear shape, one flank a fault that is dissected and reversed, great displacement of high points of deep and shallow strata, devastating destruction, footwall developed drag anticline	Huoyan Shan anticline
		Shear-compression anticline	Reversed anticline	Moderate to gentle amplitude, located in oil generating depressions, good matchup of generation and reservoiring traps	Shengbei, Singim anticlines
			Normal flower-shaped structure	High amplitude, deep, moderate, and shallow enclosure areas forming small, large, and small date-pit shapes, plastic strata thicker and broken in central parts, many high points	Kekeya, Qiuling, Hongshan anticlines
			Shear fracture anticlines	High amplitude, many high points, form echelon-shaped rows, distributed on the upthrust side of faults, dissected near one flank of faults	Yilahu, Yanshankou No 2 anticlines
			Shear anticlines	Plastic strata thicken in center, with some penetration, series of high points form echelon-shaped rows	Sishili Dadun Nos 1, 2, 3
		Bedrock growth anticlines	Bald-headed structures	Broad, gentle, high amplitude, equiaxial, large area	Takequan, Kendeke
			Short-axis anticlines	High amplitude, equiaxial, weak destruction	Shanshan (Piqan) anticline
	Fault-block type		Fault nose	Sealing of faults depends on lithologic combination at time fault was created and cut-off fault	
			Fault-block		Wenjisan, Bakan
Stratigraphic-lithologic traps			Stratigraphic unconformity	In the western depression, most are capped by the Tertiary and were created late; in the eastern depression, most are capped by the Jurassic and were created early	Burjia Nos 1, 2, Kendeke strata
			Strata overlap		
			Hydrocarbon plug	Oil strata outcrop at surface, laterally subject to lithologic closure, small scale	Qiktim
			Lithologic	Not subject to structural control, alternate with oil generating strata	Shanshan oil field Sanjianfang lower oil group
Compound traps			Structural-lithologic	Not subject to control by high points, distributed on slope positions on the flanks of structures	Sinjinkou, Taoergou

2. Semi-comatured type traps: This refers to traps that formed slightly later than the period of oil and gas formation and large-scale drainage or at the time the oil and gas matured and was discharged in large amounts. The structure amplitudes are relatively small and no oil and gas re- migrated in after the formation of structures on a large scale. A prominent characteristic of this category of traps is that the closure area and closure amplitude are both very large but their oil charge is usually not plentiful and they tend to be large structures with small oil pools.

3. Non-comatured type traps: This refers to traps that were formed much later than the period of oil and gas maturation and large-scale discharge or traps in positions very distant from the primary direction of oil and gas migration, so there is a very small probability that they received oil and gas. There are quite a few traps of this category in Turpan-Hami Basin. The large number of traps formed during the Xishan period fall into this category if they did not overlap paleostructures.

III. Basic Categories and Characteristics of Oil and Gas Pools

To fully reflect the unique characteristics of oil and gas accumulation and oil and gas pool formation in Turpan-Hami Basin, on the basis of observing the oil pool classification principles of predecessors, the interrelationship between the oil and gas migration and trap formation periods were included in the oil pool categories. Thus, the basic categories are divided into categories by trap formation factors, shapes, and sheltering conditions and into subcategories according to the interrelationship between the periods of trap formation and oil and gas maturation and migration. In this manner, each basic type can be divided into comatured plentiful type, semi-comatured non-abundant type, comatured but subsequently destroyed type, and non-comatured poor type oil pools (Figure 2 [not reproduced]).

A. Comatured plentiful type oil and gas pools

In this category are traps whose development was basically complete when the hydrocarbon source rock around the traps began to mature and entered the hydrocarbon discharge and migration period. During the subsequent process of multiple periods of trap reinforcement, they were still replenished by oil and gas. In summary, there is an excellent match between their trap development history and oil and gas maturation and migration history. Their characteristics are: 1) A high degree of oil pool filling and large oil column height; 2) Traps are near oil sources and occupy paleouplift positions, and received oil and gas supplies over long periods and on many occasions; 3) Excellent matchup of generation, reservoiring, capping, entrapment, migration, and accumulation, with a generation and reservoiring combination that is a lateral formation type of generation and reservoiring in the same rock or generation below and reservoiring above; 4) Multiple strata systems supplied the oil and gas and there were abundant oil sources. There are three oil pools in Turpan-Hami Basin, the Shanshan, Qiuling, and Wenjisang, that have been confirmed to be oil and gas pools that fall into this category. The first two have an oil column height of more than 316 to 800 m. There are also oil and gas accumulations awaiting discovery and confirmation in the Sidaogou, Kekeya No 2, Youka No 2, and other traps.

Shanshan oil pool is a plentiful type anticline oil pool. The results of evaluation of exploratory drilling indicate that the entire scope of the structure is full of oil and gas and that the oil strata may penetrate faults and connect with Qiuling oil pool to the north. The oil column height is 209 to 316.1 m. Thus, analysis of the formational process and characteristics of Shanshan oil pool would be extremely enlightening for understanding the basic characteristics of comatured plentiful type oil and gas pools.

Shanshan oil pool is located about 28 km northeast of the Shanshan County seat on the Shanshan structure (formerly called the Taibei structure) at the southeast end of the Kekeya-Shanshan anticline zone. There is a reverse fault with at NE strike on its northwest side that separates it from Qiuling oil pool, but the oil strata in both oil pools are connected and the oil and water systems are unified.

The first discovery well in Shanshan oil pool was the Taican-1 well. This well produced an industrial oil flow with a daily output of 25.9 m^3/d when logged on 5 January 1989. The generation strata was the Jurassic system Sanjianfang group, followed by the Qiktim group. The Xishanyao group also produced an industrial oil flow.

The characteristics of Shanshan oil pool are "three larges, two highs, and four lows". "Three larges" refer to the great thickness of the oil strata, the large amplitude of the traps, and the great height of the oil column. "Two highs" refer to the high oil-gas ratio and high elastic recovery rate. "Four lows" refer to the low oil strata pressure, low reservoir strata permeability, low crude oil specific gravity (0.82 to 0.812), and low oil-bearing saturation. This is particularly true for the great oil column height, which is a unique characteristic of its plentiful oil charge. After nearly 20 exploratory wells, assessment, and confirmation, there is no interbedded water in an oil-bearing well section several 100 m long, so it has a unified oil-water boundary (Figure 3), indicating that it has integral oil-bearing characteristics.

Shanshan structure was strengthened and given final shape by the effects of shear-thrust during the Xishan period and is located between the Taibei and Qiudong depressions. Analysis of its sedimentation history indicates that for at least the Xishanyao period during the middle Jurassic era, the sedimentation system within the scope of the structure indicates that above-water sediments predominated and it would appear that the rate of subsidence within the scope of the structure was lower than the supply rate of sediments so obvious paleostructures exist. As a result, sand bodies developed nearby to the right and left. Analysis of the history of the structure's depth of burial indicates that this structure was

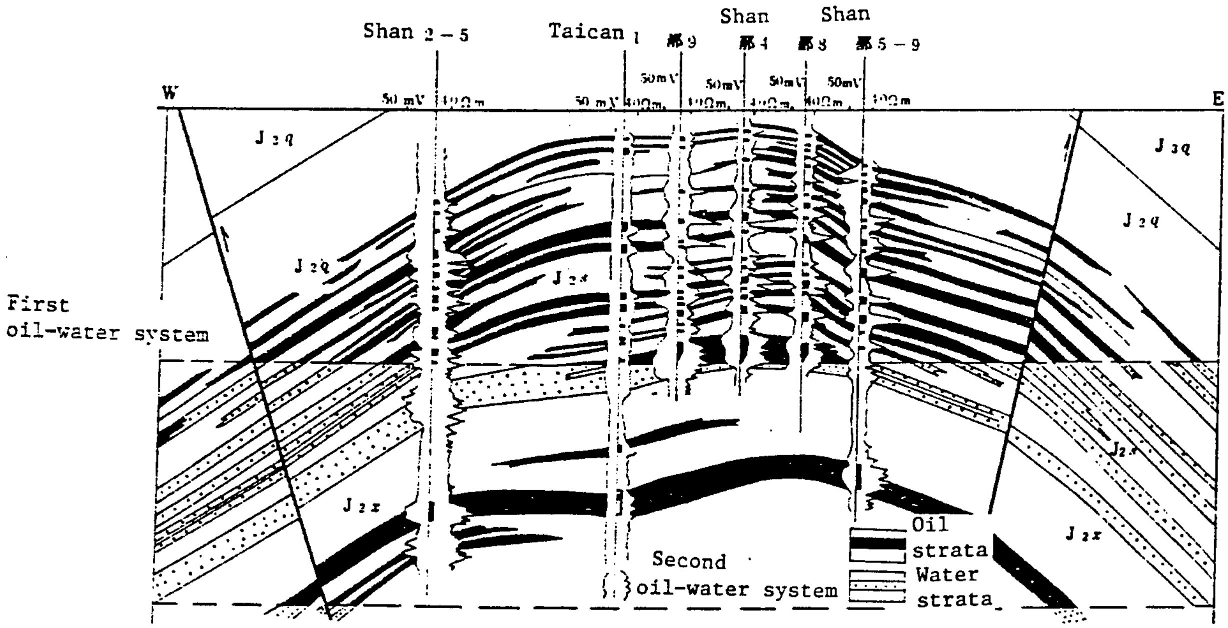

Figure 3. Shanshan Oilfield Shan 2-5 Well to Shan 5-9 Well Oil Pool Cross-Section

formed relatively early. Figure 4 [not reproduced] illustrates the geological conditions of oil formation in Shanshan structure. This article uses differences in the burial history curves of the oil supply region and top of the structure to analyze the formation periods of the paleostructure. In the illustration, the lines with dots represent the subsidence curve of the oil supply region while the solid lines reflect historical changes in burial of the top of the structure. It is easy to see from the differences in the slopes of the two curves that Shanshan structure had at least been created by the late Jurassic. The right half of the figure analyzes the oil and gas maturation history. Taican-1 well in the top of the structure determined the oil generation window limits and a reverse inference is made about the earliest period of oil and gas maturation and hydrocarbon discharge in the oil generation region. One can see that the lower Jurassic system Badaowan group oil generating strata had at the least matured and discharged hydrocarbons during the late Jurassic. Shanshan structure had already been formed by that time so it was quite natural for the oil and gas to migrate here. Comparison of oil sources indicates that the oil and gas in Shanshan oil field came mainly from the Badaowan group and that it was generated in lower rock and reservoired in upper rock. Thus, at the end of the Jurassic, the scope of the structure had an excellent matchup of reservoiring, entrapment, migration, and accumulation. We also noted that the backwater of the lake basin during the Qiktim period covered the Shanshan structure. Thus, after Jurassic sedimentation, the scope of the structure had uplifts as well as reservoir strata and had oil sources as well as preservation conditions. This is the basis for the formation of excellent accumulations in Shanshan structure.

During multiple instances of tectonic movement at the end of the Jurassic, the end of the Cretaceous, and during the Xishan period, the Shanshan structure was reinforced and never destroyed, so the structural amplitude was increased again. During this process, there may have been several main periods of oil and gas migration toward this region, but the migration never ceased from beginning to end. According to TTI research, the Jurassic system hydrocarbon source including the Qiktim group is still migrating today and has never stopped. Thus, the structural background and the concentrated development of reservoir rock, the regional capping strata and the reinforcement of the traps, the preservation conditions and the long-term migration process determined the formation of block-shaped oil and gas pools with high oil columns and high abundance in Shanshan structure.

The above analysis shows that plentiful-type oil and gas pools are related to favorable aspects in every area of oil and gas accumulation. At the same time, it also shows us that we should treat the entire Kekeya-Shanshan anticline zone as a unified oil and gas accumulation zone. First, a unified oil and gas accumulation combination with a series of high points moving from low to high may have formed running from Shanshan through Qiuling and on to Kekeya. A gas top with this combination exists in Kekeya anticline (Figure 5). Second, because the primary activity of the two sides that support this anticline zone on the sloping thrust faults was during the Xishan period, there should be some residual oil pools after being dissected on the footwall of these two side faults and the scale of the oil pools there may be even larger.

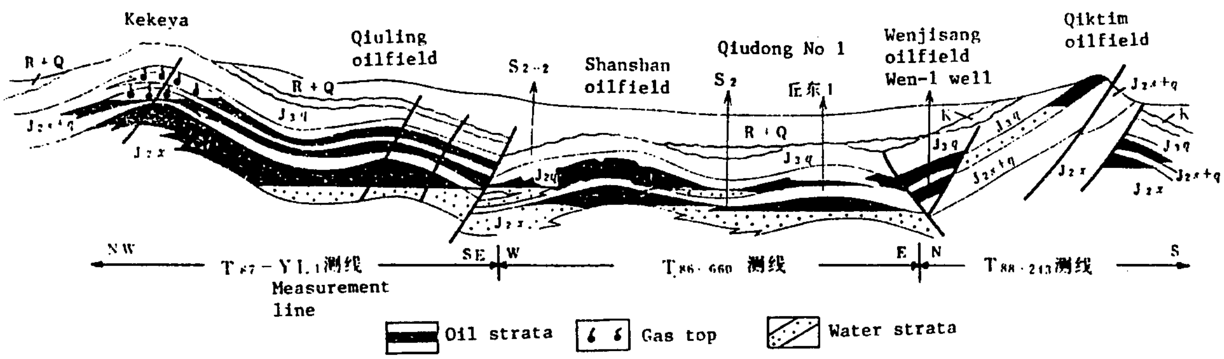

Figure 5. Kekeya-Shanshan-Qiktim Oil Pool Model

B. Semi-comatured non-plentiful type oil and gas pools

These are traps that were not fully developed and of limited amplitude when the hydrocarbon source rock surrounding the traps matured and began discharging large amounts of hydrocarbons. After the traps were further reinforced, there was no oil and gas to replenish them so the traps do not have abundant charges of oil. Their characteristics are: 1) Trap closure areas and amplitudes are both relatively large, but the oil-bearing area and oil column heights are both rather small; 2) The traps are relatively distant from oil sources and have a rather scant relationship to the primary direction of oil and gas migration and discharge; 3) The matchup of generation, migration, accumulation, and trapping conditions is less than ideal; 4) The generation and reservoiring capping combination is mainly generation in older rock and reservoiring in newer rock, with generation below and reservoiring above and a lateral generation pattern. The oil pool in this category that has been discovered already in Turpan-Hami Basin is the Yilahu oil pool. The Yanshankou No 2, Kendeke, Yarhu, and other structures also may have this category of oil pools that await further work.

Yilahu oil pool is a typical non-plentiful type fault-anticline oil pool. This has been confirmed by one exploratory well and two evaluation wells. Yilahu oil pool is located in the hanging wall of the Toksun north thrust fault, which has a NE strike, in the Yilahu anticline at the extreme southwestern end of the Yilahu-Yanshankou anticline zone, about 45 km from the Toksun County seat. This oil pool was discovered at the Tuocan-1 well, which was finished on 16 May 1989. A high-output oil flow with a daily output of 40 m^3/d was obtained from the middle and upper Triassic system Karamay group. Comparison of oil sources indicates that the oil and gas came from the Permian system.

The basic characteristics of Yilahu oil poor are "two larges, four highs, two lows, and four smalls". "Two larges" refer to the great total thickness of the reservoir strata (the total thickness of Triassic system sandstone and sandy conglomerate is 175 m, equal to 45 percent of the thickness of the strata group) and large trap amplitude (245 m). "Four highs" refer to the high strata pressure (strata pressure coefficient 1.05), high oil strata porosity and permeability (15.6 percent, 60.9 X 10^{-3} to 400 X 10^{-3} μm^2), and high single well output. "Two lows" refer to the low crude oil specific gravity (0.834) and low oil-gas ratio (49.5 to 53.7 m^3/t). "Four smalls" refer to small oil column height, small oil strata thickness, small oil-bearing area, and small geological reserves. Interpretation of electrical logging and oil tests confirm that there are a total of three oil strata, but the thickness of the oil strata is just 15.6 percent of the thickness of the sandstone. Moreover, there is obvious bottom water in each of the oil strata (Figure 6).

After analyzing the basic characteristics of Yilahu oil pool, it was discovered to have some unique properties. First, the area and amplitude of Yilahu anticline are both rather large but the discovery well revealed that the structure does not have a plentiful charge of oil, its oil charge being less than 40 percent. Second, Jurassic system structures are intact and there is no absence of reservoir strata, but they do not contain oil and may even have very weak indications of oil and gas. If the oil and gas migrated into the Jurassic system structure after its formation and came from the structure itself, the Jurassic system should have oil and gas.

Based on these conditions, the following analysis can be made of the formation process of Yilahu oil pool.

The Yilahu structure is a paleostructure whose earliest formation occurred at the end of the Triassic. However, the results of analyzing eroded strata and the qualities of several instances of tectonic movement since the mid-Mesozoic indicate that the formational period of this structure was during the Jurassic era and Xishan period. The oil generation window limits determined by the Tuocan-1 well was used to make a reverse inference of the earliest maturation and hydrocarbon periods of the oil supply region and it was determined that at the latest, the oil and gas in the Permian system had already matured and been discharged at the end of early Jurassic sedimentation (Figure 7). Although there was a structure at Yilahu at this time, its amplitude was limited, as was

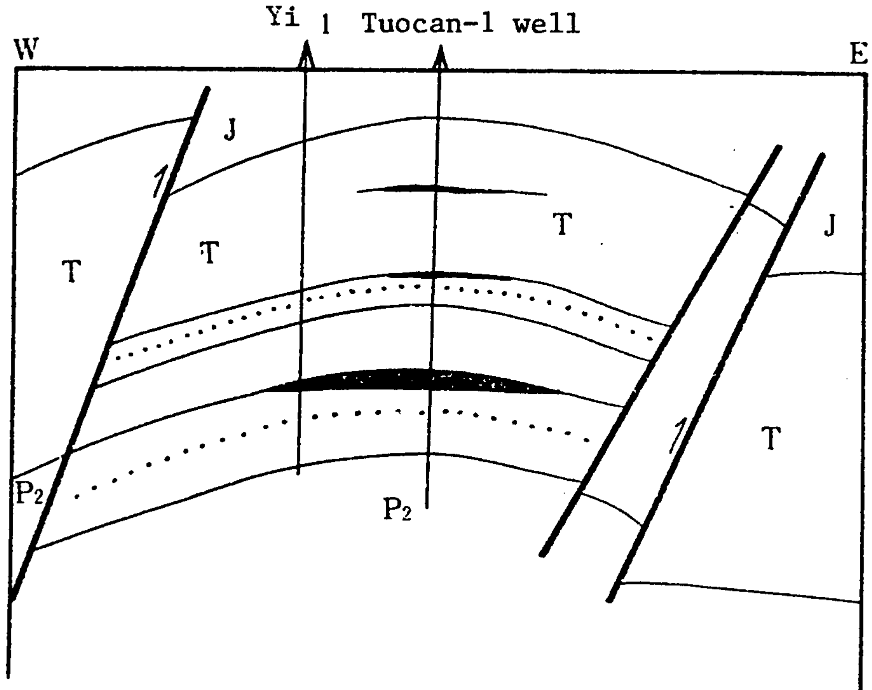

Figure 6. Yilahu Oilfield Cross-Section

the number of times it had received oil and gas. At the time of large- scale structural formation at the end of the Jurassic, however, the new Toksun north thrust fault zone also formed between it and Toksun depression. The second step in the reverse thrust zone impeded the re-migration of oil and gas into the structure. This is the key to the less than abundant charge of oil in Yilahu structure.

This analysis aids in assessing the oil-bearing properties of a series of structures in the entire Toksun north thrust fault anticline zone and shows that the second step in Toksun north thrust fault zone may have good oil-bearing properties.

C. Comatured but subsequently destroyed type oil pools

This refers to traps that formed simultaneously with oil and gas maturation and migration, but after the oil and gas accumulated, the oil and gas that had already formed was destroyed and readjusted by tectonic movement and fracturing activity and reached a new equilibrium in a new environment. The characteristics of this category of oil pools are: 1) Many or few oil and gas indications at the surface, even the appearance of some thick oil strata; 2) The degree of rich accumulation of oil and gas became poorer because of dissipation, but several ancient oil pools that were not destroyed are preserved on the footwalls of faults with a rather good degree of rich accumulation; 3) The action of groundwater and free oxygen on the top parts of oil pools caused the oil and gas to thicken and form hydrocarbon plugs or structural-lithologic traps that are thick above and thin below or thick on the top and thin on the flanks; 4) The distribution of oil and gas became more complex. The Sinjinkou and Qiktim oil pools discovered in Turpan depression during the 1950's belong to this category. Moreover, there is a possibility of this category of oil pools in the Bogda premontane anticline, Hongshan, and other structures.

The objective in analyzing comatured but subsequently destroyed type oil and gas pools is to search for and discover oil pools that have not been destroyed so far and still exist.

Sinjinkou oil pool is representative of this category of oil pool. Analysis of its formation and change processes is extremely enlightening in making breakthroughs in the search for oil in the entire central anticline zone in Turpan depression.

Sinjinkou oil pool is located on the slope around the east of Sinjinkou anticline in the western section of the Huoyan Shan anticline zone. The surface anticline has a reversed shape that is steep in the south and gentle in the north. The upper part of the Jurassic system and the Cretaceous and Tertiary systems outcrop in the central part. Beneath the surface, it is a fault-anticline whose southern flank is dissected by a thrust fault. Calculated on the basis of the -600 m sealevel contour line of the structural map of the top part of Qiktim oil strata, the closure area is 7.8 km^2 and the closure amplitude is 800 m. There is also a group of normal faults with NW strikes at the top of the structure that run nearly parallel with the long axis of the structure. The separation is generally

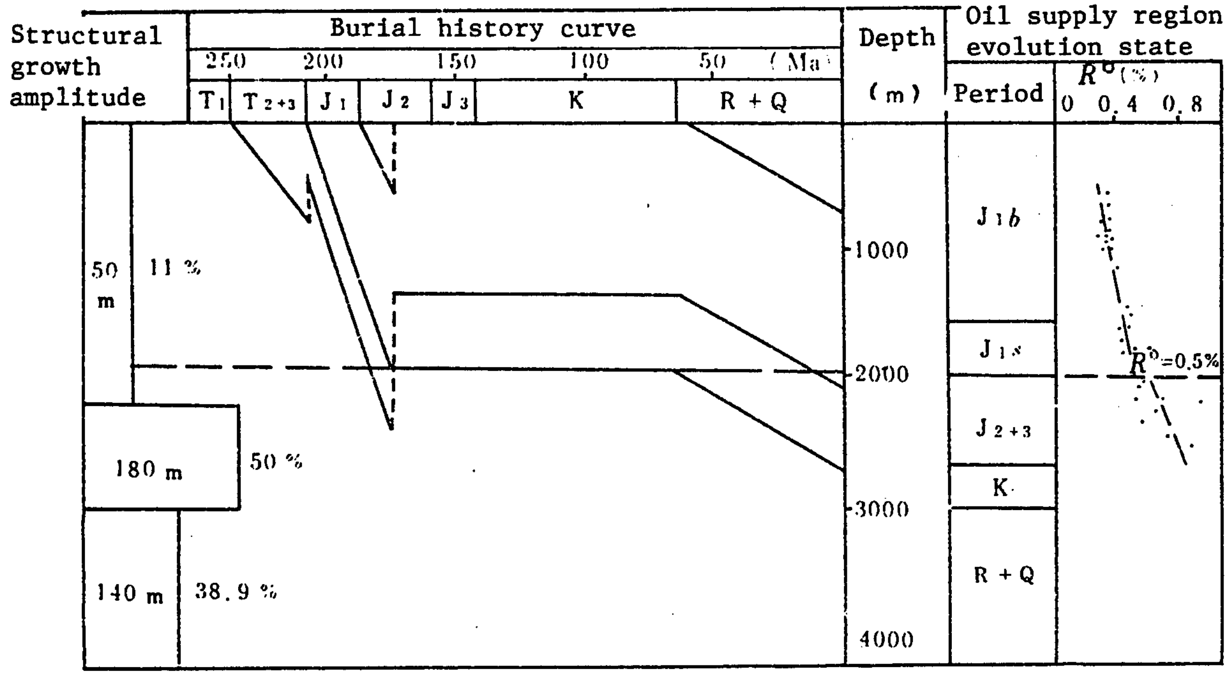

Figure 7. Yilahu Oil Pool Oil Formation Conditions Distribution Chart

< 10 m and the maximum is 130 m. A fractured and broken zone in the central part of the structure gives the main body of the structure open characteristics. There is also a complete anticline structure on the footwall of the fault on the southern flank of Sinjinkou structure.

The true Sinjinkou oil pool is a structural-lithologic trap on the slope around the east of the underground Sinjinkou structure that was formed because of lithologic sealing on a structural background (Figure 8). This oil pool was discovered in November 1958 and the discovery well was the Sheng-4 well. The daily output of crude oil was 18 m^3/d in the initial test. The primary oil strata are the Jurassic system Qiktim group followed by the Sanjianfang group.

The basic characteristics of Sinjinkou oil pool are also "three larges, two highs, two smalls, four lows, one fast, and one dissipation". "Three larges" refer to a large total thickness of reservoir strata (78 m), large entrapment area (7.8 km^2), and large amplitude (800 m). "Two highs" refers to a high oil-gas ratio (450 to 700 m^3/t) and high initial output from the oil well. "Two smalls" refer to a small oil-bearing area (accounting for 18 percent of the area of the trap) and small oil strata thickness (accounting for 20.8 percent of the total thickness of the reservoir strata). "Four lows" refer to low oil strata pressure (oil strata pressure coefficient 0.97), low specific gravity of the crude oil (0.816), low permeability of reservoir strata (2 X 10^{-3} to 18 X 10^{-3} μm^2), and low oil-bearing saturation. "One fast" refers to the rapid gradient of oil well output. "One dissipation" refers to the small single strata thickness and large number of strata (24 strata) of the reservoir strata with rapid lateral pinch-out, bifurcation, and merging.

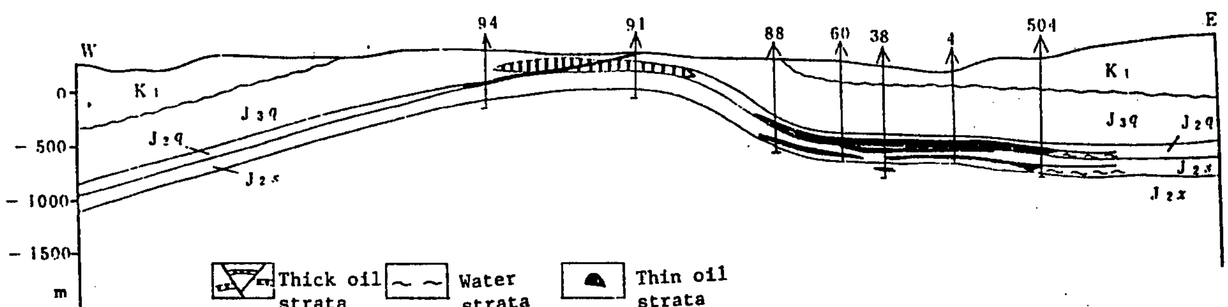

Figure 8. Sinjinkou Oil Pool Cross-Section

The successor to Sinjinkou oil pool was Taibei deep depression. This was the primary oil generating depression in Turpan depression. Its history of subsidence shows that the Jurassic system Qiktim group in the depression had already been buried at a depth of more than 3,000 m during the middle and later periods of Cretaceous sedimentation and that were was undoubtedly mature oil generation, whereas the period of lower Jurassic system Badaowan group oil generating rock maturation and discharge may have occurred even earlier. Comparison of oil sources indicates that Sinjinkou's oil and gas came mainly from Jurassic system Qiktim group lake facies oil generating rock and that the oil and gas accumulations were generated and reservoired in the same rock. However, Sinjinkou anticline obviously was formed by the effects of thrust faulting during the Xishan period and it is very clear on the surface that the structure's formation period did not match its oil and gas maturation and discharge period. Nevertheless, analyzing the surface Sinjinkou anticline and the concealed anticline structure buried on the footwall of the modern fault as a single entity shows that the entire Sinjinkou structure was created at least by the late Jurassic or even earlier. This is confirmed by the following aspects: 1) There are huge differences in thickness of the Jurassic system on the southern and northern sides of the central anticline zone. The thickness in the northern part is nearly double that of the southern part. The primary cause of the difference in sediment thickness is an obvious thickening of the middle and upper Jurassic system including the Sanjianfang group in the northern depression region. It would appear that the central anticline zone was a key zone for alternation and transition in the northern and southern sedimentation systems after the middle Jurassic. 2) Analysis of the sedimentation environment of the Sanjianfang and Qiktim groups indicates that the central anticline zone is an alternation zone between the southern above-water and northern underwater sedimentation environments. Most of the deltaic sand bodies are distributed along this zone, so there should be a background of "ancient high points". Thus, the ancient Sinjinkou structure located at high parts of the southern side of the Taibei depression should be a primary position for oil and gas migration and accumulation. The interrelationship of oil and gas maturation to structure formation and development in the depression region would seem to indicate that there is an extremely great possibility that oil and gas accumulations existed in the ancient Sinjinkou structure before it was dissected during the Xishan period.

Intense compression during the Xishan period transformed structures from previous periods, causing the northern flank of the paleostructure to be dissected and carried upward and to be inverted. At the front margin of the upthrust block, the rock strata were arched and formed extension fractures, which created a group of normal faults extending from the oil strata to the surface, causing the oil and gas that had already accumulated to be dissected and undergo readjustment. Part of the oil and gas was destroyed and some re- accumulated in the new environment. The area near the normal fault zone at the top of the modern-day structure may have generated water and no oil or the rock cores may contain oil but not produce oil. The strata water, however, is typical $CaCl_2$ oilfield water with a very high degree of mineralization. Thick oil was also produced toward the eastern part between the broken zone at the top and the thin oil pools, and the crude oil has a specific gravity of 0.937 and a viscosity of 16 to 40 MPa. All these would appear to be traces left behind by the destruction of ancient oil pools. Thus, this article views Sinjinkou oil pool as a comatured but subsequently destroyed type structural-lithologic oil pool. Besides explaining that the reason Sinjinkou oil pool is not charged with plentiful oil was because subsequent destruction caused the oil and gas to dissipate, this inference even more importantly submits for attention the possibility of an even higher oil charge abundance and even larger scale ancient oil pools on the footwall of the modern-day Sinjinkou anticline. This conclusion conforms to the analysis of the oil-bearing properties of the footwall of the entire central fracture-anticline zone.

D. Non-comatured poor-type oil and gas pools

These refer mainly to the lack of development of traps after maturation of the hydrocarbon source rock and large amounts of discharge around traps. Thus, their conditions for receiving oil and gas accumulations were rather poor. The "poor" in this category refers to the very small scale of oil and gas accumulation and mainly concerns oil and gas still being generated and migrating during the Xishan period or oil and gas that re-migrated from oil and gas pools that were destroyed during the Xishan period. The characteristics of this category of oil and gas pools are: 1) The traps were formed during the Xishan period and are unrelated to paleostructures; 2) They are distributed mostly in depressions and have poor matchups of generating, reservoiring, and capping conditions; 3) Their oil and gas is mainly secondary accumulations. Non-comatured poor-type oil and gas pools are the worst category in this article. The objective in classifying this category of oil and gas pools is to take into consideration the large number of new structures from the Xishan period in Turpan-Hami Basin and to draw attention to the fact that although there are many local structures in Turpan-Hami Basin, not all of them contain oil.

IV. Laws of Oil and Gas Accumulation

Here, we will integrate the general laws of oil and gas accumulation with the unique characteristics of oil and gas distribution in Turpan-Hami Basin to unify the general with the individual and establish an oil and gas distribution model for Turpan-Hami Basin.

1. The frequent alternation of oil reservoiring and generating strata and the non-homogeneity of oil reservoir strata determine the short migration distance of the oil and gas. At the same time, the restricted scope of the lake basin and the limited lake intrusion and expansion caused most of the excellent oil generating, reservoiring,

and capping combinations to be distributed along the margins of the primary subsidence region. It has now been determined that there are three primary oil generating depressions in Turpan-Hami Basin. They are the Yuergou-Toksun depression, Taibei-Qiudong depression, and Hami Sandaoling-Dananhu depression. The peripheries of these depressions are favorable locations for oil and gas accumulation. The distribution of the already discovered Shanshan, Qiuling, Wenjisang, Qiktim, Sinjinkou, and Yilahu oilfields conforms to this law (Figure 9 [not reproduced]).

2. Multi-strata system oil generation and multi-strata system oil reservoiring (Figure 1). Capping strata with a regionally stable distribution control the distribution of the primary generating, reservoiring, and capping combinations (Table 2 [not reproduced]). Existing data indicate that the primary generating, reservoiring, and capping combination in Turpan-Hami Basin has the Qiktim-Sanjianfang group mudstone as capping strata, Sanjianfang group sandstone as reservoir strata, and all oil generating strata below the Qiktim group as a source rock generating, reservoiring, and capping combination, as well as the mudstone of the upper of the Xishanyao group serving as capping strata with sandstone in the lower part serving as reservoir strata, and with the lower Jurassic system Badaowan group and Permian system serving as a source rock generating, reservoiring, and capping combination that controls the primary oil and gas accumulations in Turpan depression. Second comes the Triassic-Permian system generating, reservoiring, and capping combination which holds the primary position in Toksun depression in the Turpan depression and in Hami depression. In addition, the generating, reservoiring, and capping combination in which oil is generated and reservoired in the same rock in the Qiktim group, Badaowan group, and Permian system is also very important, and more discoveries will be made with more intensive exploration.

3. Paleostructures control the distribution of primary oil and gas accumulations. The paleostructures here mainly refer to structures that appeared in the middle and late Jurassic. It is quite obvious that this category of structures controlled the development of reservoir rock during the sedimentation stage, so they hold the advantage in the generating, reservoiring, and capping matchup and provide exceptionally advantageous conditions for the formation of oil and gas pools. The primary oil and gas accumulations in Turpan-Hami Basin were discovered in paleostructures, whereas new structures from the Xishan period had poor oil accumulation conditions.

4. Oil and gas accumulations were controlled by shear anticlines, strata erosion pinch-out zones, and lithologic pinch-out zones that developed on the background of paleouplifts, and they have compound oil and gas accumulation characteristics. In Turpan depression, the main oil and gas accumulation zones are shear anticline zones and thrust zones which caused the formation of compound bodies composed of shear anticline, fault-block, fault nose, lithologic, structural-lithologic, and other oil pool categories. Strata erosion unconformities are the primary aspect in Hami depression and caused the formation of strata unconformity, structural-stratigraphic, fault- lithologic, anticline, and fault-block oil and gas pools (Figure 10).

The main compound oil and gas accumulation zones in Turpan depression are at the western, southern, and eastern margins of the main Taibei depression and the northern and western flanks of Toksun depression, forming a recumbent X- shaped compound oil and gas accumulation zone (Figure 9). The main compound oil and gas accumulation zone in Hami depression is "a zone matched with a ring". "A zone" refers to the Sidaogou-Sanbao anticline zone which developed mainly anticline and structural-stratigraphic oil and gas pools. "A ring" refers to the oil and gas accumulation zone around the outer margin of Santongling-Dananhu depression which is mainly a strata erosion and pinch-out zone and lithologic pinch-out zone.

Shanshan-Qiuling anticline zone in Turpan depression is a compound oil and gas accumulation zone that is mainly shear anticlines, fault anticlines, and fault blocks. The shear anticlines and fault anticlines are the primary oil pool categories. Moreover, fault-block, fault-lithologic, fault nose, lithologic, and a variety of other

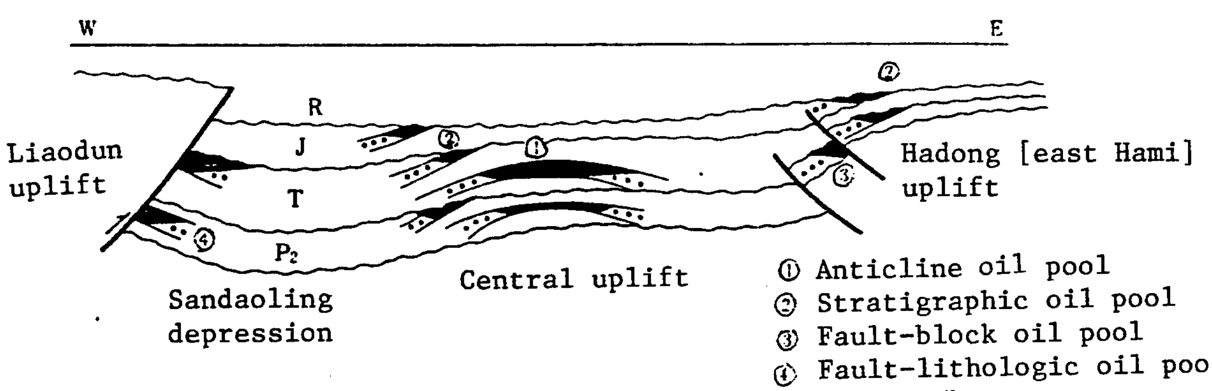

Figure 10. Hami Depression Compound Oil and Gas Accumulation Model Projection

types of oil and gas pools developed above, below, and at the flanks of the primary oil pools, forming a compound oil and gas accumulation zone.

V. Conclusions

1. In focusing on the unique characteristics of oil and gas accumulation in Turpan-Hami Basin, with a prerequisite of classifying oil and gas pools into structural type, stratigraphic-lithologic type, compound type, and other basic categories, each category of oil and gas pool can be further classified on the basis of the interrelationship of the period of trap formation to the period of oil and gas maturation and migration into comatured plentiful type, semi- comatured non-plentiful type, comatured but subsequently destroyed type, and non-comatured poor type oil and gas pools. This classification program helps increase the success rate in exploration.

2. The formation of plentiful type oil and gas pools benefitted from a favorable combination of the following geological conditions: 1) Traps formed earlier than oil and gas maturation and discharge; 2) Traps located in primary oil and gas discharge regions and near oil generation centers; 3) Transformation by late Xishan movement that strengthened the scale of structures without causing destruction; 4) Having excellent generating, reservoiring, and capping combinations, and good capping strata conditions; 5) Traps received oil and gas supplies during multiple periods.

3. The disadvantages of the non-plentiful charge of oil in non-plentiful type oil and gas pools are: 1) Traps were created after the period of large-scale discharge of oil and gas, so that after the traps had formed on a large scale, there was no oil and gas available for re-supply; 2) Trap locations are not good, so it was hard for them to receive continual supplies of oil and gas; 3) The generating, reservoiring, capping, trapping, and migration matchup conditions are rather poor.

4. Oil and gas pools are controlled by paleouplifts, paleoslopes, fault- anticline zones, and strata erosion pinch-out zones and have the characteristics of compound oil and gas accumulations. Turpan depression developed as a compound oil and gas accumulation zone dominated by stratigraphic oil and gas pools. On a planar view, they form a recumbent X- shaped favorable oil-bearing zone. Hami depression mainly has stratigraphic- lithologic and structural oil and gas pools along with some compound oil and gas accumulation zones. On a planar view, they form a zone matched with a ring. This conclusion helps in establishing different guiding ideologies for exploration and selecting appropriate oil exploration methods for the two depressions.

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Extent of Ordos Gas Find Being Tested

926B0061B Hohhot NEIMENGGU RIBAO in Chinese 27 Nov 91 p 1

[Article by Zhang Shuxin [1728 2579 0207]: "Prospecting For Natural Gas in Ordos Basin Shows Good Promise; steady Flow of Natural Gas From Five Ordos Wells"]

[Text] Dongsheng dispatch. The Eighth 5-Year Plan prospecting project undertaken by the North China Petroleum Geology Bureau of the Ministry of Geology—the Ordos natural gas prospecting project—has struck pay dirt for the first time. An 8 millimeter flow nipple trial brought in a steady gusher of 10,394 cubic meters of natural gas per day. This prospecting tract is located in the eastern section of the northern part of the Yishen declivity in the Ordos Basin covering an area of 5,000 square kilometers. Work done by the North China Petroleum Geology Bureau in recent years found this area to be a favorable site for a natural gas reservoir. This area's natural gas reserves are estimated at 2 trillion cubic meters.

Now five Ordos wells that the North China Petroleum Geology Bureau's Sanpu 5007 crew opened are in the process of enlarging the test results. The next step is to be testing of the well's main gas bearing formation. Both the abnormal value and the thickness of the gas formation have been found to be nine times and 3.3 times respectively that of the formation that has been tested. Prospects are even more considerable.

Fusion-Fission Hybrid Breeder and Its Role in Nuclear Power Development

926B0045B Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 12 No 6, Dec 91 pp 12-17

[Article by Sheng Guangzhao [4141 0342 2507] and Huang Jinhua [7806 6930 5478] of the Nuclear Industry's Southwest Institute of Physics: "Fusion-Fission Hybrid Breeder and Its Role in Nuclear Power Development"; MS received 21 May 91]

[Text] **Abstract:** The principle and function of the fusion and fission-fusion hybrid reactor are briefly described. The hybrid breeder can provide sufficient fuel for a PWR or FBR. A system consisting of fusion-fission hybrid breeders and PWRs or FBRs is economically viable. The hybrid breeder will play a key role in solving the fission fuel shortage problem for large-scale development of nuclear power in China and maintaining the momentum in the development of pure fusion energy.

Key words: nuclear fusion, fusion-fission hybrid breeder.

I. Introduction

Heavy nuclear (U, Pu) fission reactions are the basis of nuclear power and other nuclear powered equipment to date. Since the first nuclear power plant was put into operation in 1954, there has been tremendous progress in the development and use of nuclear power. At present, nuclear power carries considerable weight in the electric power system in several developed countries. The construction of Qinshan and Daya Wan power plants is an important step for the nuclear power industry in China. Because of the limited availability of fission fuel and some inherent shortcomings of fusion reactors (such as highly radioactive fission products), as early as 1950 researchers began to explore the fusion of light nuclei (deuterium, tritium) as a clean energy source with an extremely abundant fuel supply. The development and application of fusion energy is a very difficult task—perhaps it is one of the most challenging topics encountered in the history of science. After 40 years of dedicated research, breakthroughs have been made in fusion research. The first milestone, i.e., a demonstration of scientific feasibility of fusion in the form of deuterium-tritium combustion, will be reached in the near future. However, the commercialization of fusion is still a long way off, probably by the middle of the next century. Hence, a system combining the mature fission reactor technology with fusion technology to create an advanced rector, i.e., fusion-fission hybrid breeder, is an effective means to solve the fission fuel shortage problem and to make use of fusion energy ahead of time.

II. Controlled Nuclear Fusion

A great deal of energy is released when light nuclei (such as the hydrogen isotopes deuterium and tritium) undergo fusion; this is fusion energy. The violent explosion of a hydrogen bomb is the uncontrolled release of this form of energy. If this energy can be released in a controlled manner for use by mankind, it will become an unlimited clean energy source to fundamentally solve the energy problem.

The primary reactions involved are:

$$D + D \begin{cases} \nearrow {}^3He + n + 3.27MeV, \\ \searrow T + P + 4.05MeV; \end{cases}$$

$$D + T \longrightarrow {}^4He + n + 17.58MeV;$$

$$D + {}^3He \longrightarrow {}^4He + P + 18.58MeV_{\circ}$$

Due to the large reaction cross section, it is relatively easy to achieve fusion with deuterium and tritium. Hence, the development of fusion energy begins with the D-T reaction.

Fusion has the following attractive features:

(1) Deuterium, a fusion fuel, is naturally abundant. The deuterium-to-hydrogen ratio in seawater is 1:6500. The energy released by the fusion of deuterium contained in a liter of seawater is approximately equivalent to that released by burning 300 liters of gasoline. If all the deuterium in seawater is used in fusion, it is estimated that approximately 10^{17} MW-a of energy can be released. This is sufficient for mankind to go on for several hundred million years. Therefore, this type of fuel is essentially non-exhaustive.

(2) The fusion fuel tritium is a β isotope which has a 12.6-year half life and does not exist in nature. Nevertheless, it may be generated by a neutron-lithium reaction in the jacket of a fusion reactor. Hence, a D-T fusion reactor actually burns deuterium and lithium. Lithium is also abundant on earth. It is estimated to last at least several thousand years for D-T reactor use.

(3) The fusion product is helium, which is non-radioactive. This is unlike fission reactors, which inherently produce some strongly radioactive wastes.

(4) There is no danger of a nuclear explosion. To make a fusion reactor generate energy, the core plasma parameters (such as temperature, density and confinement interval) must satisfy certain conditions. Once these conditions are not met, the fusion reaction will self-terminate.

(5) High-energy neutrons generated by the D-T fusion reactor may induce structural materials to become radioactive. By proper selection or development of structural materials, it is projected that the fusion reactor is going to be far less radioactive than a fission reactor. Furthermore, these materials are solids which are easy to process and will not pollute the environment.

In order to obtain sufficient energy from fusion, the following three conditions must be met. (1) The fuel must be heated to an extremely high temperature. The minimum temperature (T) is approximately 100,000,000°C for D-T fusion and 500,000,000°C for D-D fusion. (At such high temperatures, matter is totally ionized, i.e., in a plasma state.) (2) The fuel must have a sufficiently high particle density (n) to be able to produce enough fusion energy. (3) The plasma energy confinement time (τ_E) must be long enough. Thus, this may be summed up as the need for the product of these three requirements $nT\tau_E$. As far as D-T fusion is concerned, $nT\tau_E \geq 2 \times 10^{21}$ m^{-3}-s-keV.

Such a high-temperature plasma cannot be confined in an ordinary vessel. Present fusion research is focused on two methods of confinement. One is inertial confinement fusion (ICF), which involves the use of a high-power laser or particle beam to rapidly heat up and compress a solid fuel to reach fusion conditions. Since the density is very high ($> 10^{22}$ cm^{-3}), the required confinement interval is relatively short (about 10^{-8} s). Because it is confined by the inertia of the fuel particle itself, it is called inertial confinement. Another method is magnetic confinement, i.e., the plasma fuel is confined by a magnetic field. In the area of magnetic confinement, the optimal plasma parameters are attained in a Tokamak. The Tokamak is close to break-even, i.e., $n(0)T_i(0)\tau_E = (8\text{-}9) \times 10^{20}$ m^{-3}-s-keV where n(0) and $T_i(0)$ are values on the magnetic axis and i represents ion. Despite this fact, pure-fusion commercial power plants still have a long way to go. The United States plans to finish the engineering of the ITER (international thermonuclear experimental reactor) by 1997 and complete its construction by 2005. A demonstration reactor will be designed by 2012 and constructed by 2025. The first commercial reactor will be designed by 2032 and built by 2040. This is an optimistic projection assuming smooth development and sufficient funding.

III. Fusion-Fission Hybrid Reactor

A fusion-fission reactor incorporates fission matter or convertible materials (e.g., ^{238}U, ^{232}Th) and some neutron doubling agents in a fusion reactor jacket in order to produce electricity and fission fuel by way of fission reactions induced by fusion-generated neutrons and to double the energy and neutrons through the (n, 2n) and capture reaction. A fusion-fission reactor that is primarily used to produce nuclear fuel is called a fusion-fission breeder.

The physical basis of a hybrid reactor is to use the fusion core as a neutron source. The neutrons are used for energy doubling, breeding fission fuel and tritium in the jacket. Every D-T fusion reaction generates a 14 MeV neutron and a total of 17.6 MeV of energy. The number of fusion neutrons per unit energy unit is four times higher than that of fission neutrons. Because one neutron is required to breed tritium, one fusion neutron alone is not enough. Therefore, it is necessary to double the number of fusion neutrons. Neutron doubling agents include ^{238}U, ^{232}Th, Be, ^{7}Li, etc. Fission materials are produced by way of the following reactions between neutrons and convertible materials:

$$n + {}^{238}U \longrightarrow {}^{239}U \xrightarrow[24\ \text{min.}]{\beta^-} {}^{239}Np \xrightarrow[2.4\ \text{days}]{\beta^-} {}^{239}Pu$$

$$n + {}^{232}Th \longrightarrow {}^{233}Th \xrightarrow[22\ \text{min.}]{\beta^-} {}^{233}Pa \xrightarrow[24.7\ \text{days}]{\beta^-} {}^{233}U$$

Just as ^{235}U, neutrons of any energy can cause ^{239}Pu and ^{233}U to undergo fission. Therefore, they can be used as fuels in light-water reactors.

Figure 1 shows two major fusion-fission reactors, i.e., fast fusion-fission hybrid reactor and suppressed fusion-fission hybrid reactor. In a fast fusion-fission hybrid reactor, the D-T fusion reactor core is surrounded by a jacket of convertible materials and lithium (^{238}U + Li, or ^{232}Th + Li, or ^{238}U + Li in front and ^{232}Th + Li in the rear). Fast fission of ^{238}U or ^{232}Th can be caused by fusion neutrons. At least one of the neutrons must react with lithium to produce tritium to replenish the tritium consumed in the core. The remaining three or so neutrons are used for breeding fission materials. In a suppressed fusion-fission hybrid reactor, the fusion core is surrounded by a jacket of tritium breeding material (Li) and non-fission neutron doubler (e.g., Be). Fusion neutrons are slowed down by this layer to below the fission threshold of the convertible material. One neutron is still needed to breed tritium and the remainder are used to produce fission fuels.

Because the fusion neutron power is amplified several fold in a hybrid reactor, the fusion core power can be lowered. Hence, the plasma confinement conditions are not as stringent as those for a pure fusion reactor. This is particularly true for a fast fission jacket. In order to evaluate the fusion requirements for a variety of hybrid reactors, two parameters are generally used, i.e., plasma power gain Q ($Q = P_f/P_{aux}$, where P_f is the fusion power and P_{aux} is the power input to sustain plasma temperature) and first-wall neutron load $(P_w)_n$ is defined as the fusion neutron power penetrating a unit area of the first wall. Usually, higher values of Q and $(P_w)_n$ indicate more rigorous physical and technical requirements. Table 1 lists the requirements for the two types of hybrid reactors and for a pure fusion reactor. In order to be able to produce nuclear fuel and electric power economically, Q must be high.

Table 1. Fusion Core Requirements for Hybrid Breeders

	Q	$(P_w)_n$, MW/m^2
Fast fission jacket hybrid	1-5	1-1.5
Suppressed fission jacket hybrid	6-15	2-3
Pure fusion reactor	Above 15	3-5

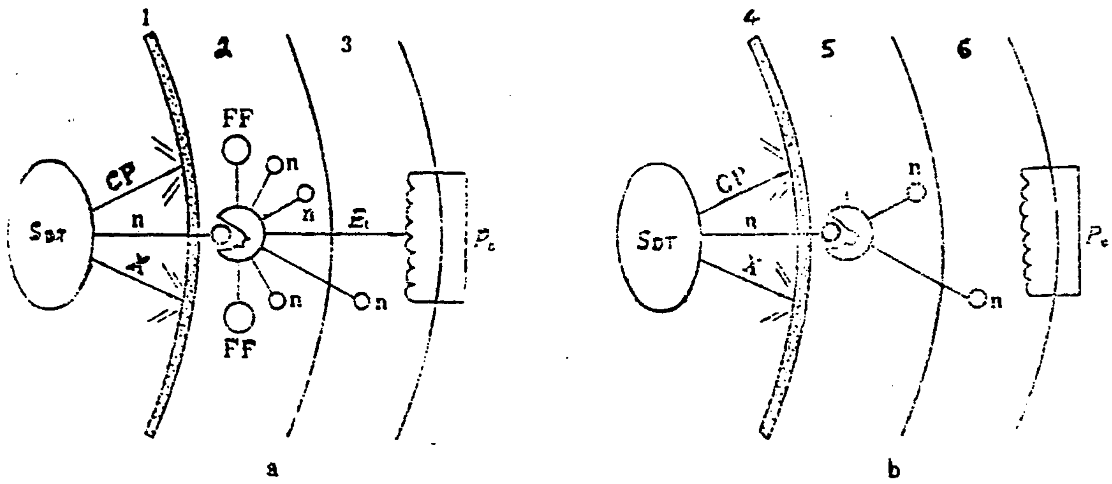

Figure 1. Schematic Diagrams of Fusion-Fission Hybrid Reactors. a—fast fission jacket, b—suppressed fission jacket

1, 4. First wall; 2. Convertible material (^{238}U and ^{232}Th), three neutrons for breeding fission fuels; 3. Lithium, one neutron used for breeding tritium; 5. Neutron doubling and tritium breeding layer, one neutron used for breeding tritium; 6. Convertible material layer, one neutron used for breeding fission fuel. S_{DT} represents the D-T fusion source, CP represents charged particle, FF represents fission fragment, E_t is thermal energy, P_e is electric power, and X represents X-ray.

The breeding ratio, F, is an important parameter representing the fuel production capability of a hybrid reactor. It is the net number of fission fuel nuclei produced by a fusion neutron. F varies as a function of the jacket design. From the jacket energy gain M and breeding ratio F, it is possible to estimate the fuel production capability of a hybrid reactor. Let us assume that the load factor is 0.7, then the amount of ^{239}Pu produced per year by each MW of thermal power is

$$N_{Pu} = 3.87 \text{ F f(M)/M (kg/MW}_{th}\text{-a)}$$

where $f(M) = 14.1M/(14.1M + 3.5°)$.

If M and F are known from the jacket design, then the annual fuel production capacity can be estimated accordingly. Usually, F and M are large for a fast fission reactor. If F = 1.5 and M = 10, then a 4,000 MW thermal power hybrid reactor (with a fusion power of 444.4 MW) can produce approximately 2,000 kg of ^{239}Pu per year. As for a suppressed fission jacket, F and M are lower because the number of fission incidents is fewer. If F = 0.75 and M = 1.6, then a 4,000 MW thermal power hybrid reactor (with a fusion power of 2,703 MW) can produce approximately 6,000 kg of ^{239}Pu per year.

Electric power systems using fusion-fission hybrid breeders to primarily produce nuclear fuels show very good promise because they can produce a great deal of fuel for many other fission reactors. Based on an estimate given in the literature, including direct, indirect and time-related investments, a fusion-fission hybrid breeder costs 2-3.4 times that of a light-water reactor of the same capacity. The analysis shows that when U_3O_8 costs $55/kg, the ratio of electric power generating cost of a system with both hybrid and light-water reactors to that of using conventional light-water reactors alone is 1.05-1.11. This means that the power generating cost of the coexisting system is only 5-11 percent higher than that of conventional nuclear power. However, when the cost of U_3O_8 rises, the electricity generating cost of a conventional light-water reactor goes up while that of the hybrid reactor declines. When the cost of U_3O_8 goes up to $200/kg, the power generating cost of the hybrid-light water reactor system is below that of conventional nuclear power.

In summary, a hybrid reactor has the following advantages. It does not need fission fuel. The breeding fission materials are potent. The power density of the fission jacket of the hybrid reactor is only 1/10-1/100 that of a fission reactor. In a hybrid breeder-light water reactor system, fuel and power are generated separately. The hybrid breeder is primarily used to produce fuel and most of the energy is generated by light-water reactors supported by the hybrid breeder. From the standpoint of fusion energy, it is a bridge between available energy source today and pure fusion energy in the future.

IV. Role of Hybrid Breeder in Nuclear Power Development in China

Based on our energy demand, large-scale development of nuclear power is required in the first half of the 21st Century. For example, the installed capacity should reach over 120 GW by 2050. This will be more than 10 percent of the total capacity (the 1989 worldwide average was 17 percent). As we know, the first-generation nuclear power plant was based on military reactor technology. It was not very fuel efficient. Large-scale use of commercial nuclear power must make full use of ^{238}U and ^{232}Th. Since nuclear fuel is not abundant in China, there is a greater urgency to develop second-generation nuclear power plants. As a breeder, the fast neutron hybrid breeder technology is more mature and should be given priority. Nevertheless, it is unrealistic to depend on fast breeders alone to achieve large-scale nuclear power by 2050. Even at a high breeding ratio of 1.58 and a 1-year processing time outside the reactor, fuel must be put into a fast breeder in the first 3 years of operation. Under the constraint of our nuclear fuel supply, if everything moves along smoothly, the total installed capacity is estimated to be 90 GW by 2050. If a high breeding ratio is not compatible with other factors such as economy and safety, the actual value will be far below the ideal value. Then, the scale discussed above must be further discounted. A hybrid reactor can produce 10 times more fuel per year than a fast reactor of the same size. Compared to a fission reactor, (1) the hybrid reactor releases less energy in each fusion reaction. Hence, fusion neutrons are produced at a higher rate at identical thermal power. (2) More than two neutrons are produced in each fission reaction in a fast reactor and one is consumed to sustain the chain reaction. This is not required in a hybrid reactor. Therefore, it has a higher breeding ratio. Hybrid breeders can completely alleviate the constraints on the scale of nuclear power development due to fuel availability.

As for the pure fusion reactor, based on an optimistic projection, it will be commercialized in 2040-2050 in developed countries. In addition to technical hurdles, making the pure fusion reactor economically attractive is an important task in fusion research. The high cost of a fusion reactor is caused by the difficulty for the first wall to sustain a very high neutron flux. This leads to a low engineering power density of 1 MW/m^3, as defined by "total thermal power/volume of fusion reactor structural material." The fusion power plant designed today costs twice as much as a fission power plant. Even this has a great deal of uncertainty. Apparently a commercial pure-fusion power plant is still a long way down the road. It is of great significance to develop intermediate applications to maintain the momentum of fusion research. A hybrid breeder may be able to play such a role. As mentioned before, it is economically attractive to use a hybrid breeder to produce fuel as well as to generate electricity. The core plasma requirement for a hybrid breeder can vary. As the quality of core plasma is upgraded, the nuclear fuel-producing capability also improves. At the present level of fusion development, a series of key technical issues, such as heating and confinement of plasma, confinement of alpha particles, development of materials (especially the first wall and high thermal load parts), remote maintenance technology, tritium technology and post-treatment of fuel, must be solved for a hybrid breeder. If we are serious about it and devote our effort to it, these problems can be addressed and overcome in 20-30 years.

In conclusion, a hybrid breeder may play a pivotal role in our nuclear power development in the first half of the next century. It will supply the fuel necessary for the large-scale development of nuclear power. In addition, it will push fusion research forward toward the development of third-generation nuclear power plants to fundamentally solve the energy problem for mankind.

V. Design Concept for Hybrid Breeder

Since the early 1980's, we have more or less completely finished the conceptual design of the magnetic mirror hybrid breeder (CHB),[1] Tokamak Engineering Test Breeder (TETB),[2,3] and Tokamak Commercial Breeder (TCB).[4] Table 2 shows the major parameters for the TETB and TCB.

Table 2. Major Parameters for TETB and TCB

	TETB	TCB
Plasma large radius R, m	4.0	6.40
Plasma small radius a, m	1.0	2.00
Fusion power P_f, MW	200.0	2,000.0
Plasma power gain Q	10	37
Neutron wall load $(P_W)_n$, MW/m^2	0.63	1.86
Mean jacket energy gain M	4.0	2.8
Breeding ratio F	0.54	0.7
Tritium breeding ratio T	1.06	1.06
Maximum thermal power P_{th}, MW		5,740
Mean thermal powerP_{th}, MW	680	4,176
Net electric power output P_e, MW		1,000
Annual ^{239}Pu production M_p, kg	100	4,300

The core fusion power of the TETB is 200 MW, plasma energy gain Q is 10, and neutron wall load $(P_w)_n$ is 0.63 MW/m^2. Liquid lithium is used as a coolant, as well as a tritium breeding agent, in the jacket. The neutron doubler is beryllium. The thermal power of the jacket is 680 MW. If the operating factor is 0.35, this reactor is capable of producing approximately 100 kg of ^{239}Pu per year.

The core fusion power of the TCB is 2,000 MW, plasma energy gain Q is 37, and neutron wall load $(P_w)_n$ is 1.86 MW/m^2. Liquid lithium is used as a coolant, as well as a tritium breeding agent, in the jacket. The neutron doubler is beryllium. The mean thermal power of the jacket is 4,176 MW and the net electric power output is 1,000 MW. This reactor is capable of producing over 4,000 kg of ^{239}Pu per year.

VI. Conclusion

In recent years, a great deal of progress has been made in fusion research. Plasma conditions equivalent to Q_{DT} = 0.7 have been achieved. Combustion experiments using

D-T plasma are expected to take place on a new generation of Tokamak facilities (e.g., JET, TFTR) in the near future to demonstrate the feasibility of fusion and to investigate the behavior of combustible plasma. In addition, ignition experiments and engineering pilot reactors are also being actively planned. After 5 years of operation, the China HL-1, which was designed and constructed in China, has produced very good experimental results. This has laid a solid foundation for the construction of larger devices as well as for the study of plasma characteristics. Since 1986, the hybrid breeder was included in the high-technology development plan. In the past 5 years, encouraging results have been obtained in the conceptual design of the hybrid breeder and related engineering experiments. As long as we can commit our resources to advanced fusion research, it is entirely possible to complete an engineering hybrid breeder by early next century and construct commercial hybrid breeders by 2030 to supply sufficient fuel for nuclear power.

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Strategic Position of the FBR in China's Nuclear Power Development

926B0045A Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 12 No 6, Dec 91 pp 7-11

[Article by Ma Dayuan [7456 1129 0954] and Yi Xiaoyi [2496 1420 3015] of the China Institute of Atomic Energy: "Strategic Position of the FBR in China's Nuclear Power Development"; MS received 4 Aug 90]

[Text] **Abstract:** Based on the forecast for energy and electricity demand up to the middle of the next century (2050), the strategic position of the fast breeder reactor (FBR) in nuclear power development is analyzed.

Key words: nuclear power, development strategy, fast breeder reactor.

I. Introduction

The uranium utilization rate of a thermal neutron reactor is very low (1-2 percent). If we only develop thermal neutron reactors, then nuclear power will eventually be limited by the amount of uranium we can economically obtain. An FBR can breed fissile materials to improve the utilization rate to 60-70 percent. After thermal neutron reactors are developed to some stage, the timely introduction of FBR can provide a thrust to nuclear power development to ensure the long-term steady growth of nuclear power. This is a common issue encountered in the long-range planning of nuclear power for every nation.

China's nuclear power industry is in its infancy. The pressurized water reactor (PWR) is the first generation reactor for nuclear power. Issues such as when to bring in an FBR, how fast and on what scale, and what the effect on nuclear power development will be, must be analyzed based on specific situations in China. Major factors involved include: our demand for nuclear power, long-term supply of uranium and our country's economic status. The discussion in this paper is limited to nuclear fuel recycling. It will serve as a reference for more detailed analysis.

II. China's Demand for Nuclear Power Development

1. Forecast of Energy Resources and Power Requirements

Our energy demand and growth rate of energy consumption depend on many factors. The most important include the rate of population increase, changes in industrial structure and effectiveness of energy conservation measures adopted (progress in science and technology). Table 1 shows several forecasts of the overall energy demand to 2050. I is an estimate of the overall energy needs based on an analysis by different sectors such as industry, agriculture, transportation, services and civilian use.[1] II is derived from macroscopic analysis of population growth, mean national product per capita and product to energy consumption ratio.[2]

Table 1. Estimates of Total Energy Demand to 2050 (100 million tons of standard coal)

Year		1980	1985	2000	2010	2015	2030	2050
I	Fast	6	7.3	14	—	20	31	55
	Slow	6	7.3	13	—	18	26	49
II		6	7.3	12.1	15.3	—	24.4	36.9

In 1985, 401.7 billion kWh of electric power was generated in China, which is 16 percent of the total energy consumed. By the end of this century, the Ministry of Water Conservancy and Electric Power estimated in its plan that the total power generating capacity will be 240 GW by 2000. Electric power will be 26-27 percent of the overall power demand. In 1980-1985, the ratio of electric power to total energy demand in developed nations was approximately 40 percent. As our economy grows, the weight of electric power will increase. Table 2 shows a forecast of our electric power development.

Table 2. Forecast of Electric Power Development by 2050

Year	2000	2015	2030	2050
Total energy demand (100 million tons of standard coal)	13.5	20	31	50
Weight percent of electric power, %	29	33	30	40
Installed capacity, GW	240	421	769	1,436

2. Analysis of Nuclear Power Development

Based on reliable data, approximately 15-21 billion tons of petroleum products can be ultimately obtained. As of now, 4.1 billion tons have been positively surveyed. Based on the ultimate upper limit, production can increase gradually from the present rate of over 100 million tons per year until it peaks in 2030 (approximately 300 million tons per year). It then tapers back down to the present level by 2050. The ultimate natural gas reserves in China are approximately 16.5 x 10^{12} m^3. They will grow at a faster rate after 2020, peaking out in 2050 (approximately 150 billion m^3 per annum). In 2050, the annual production of natural gas will be equivalent to 41.3 billion tons of standard coal. This is only 8.6 percent of the total energy demand. Our hydropower resources are expected to be almost fully developed by 2030. Total installed capacity is approximately 263 GW which can generate 920.5 billion kWh of electricity per year; this is merely 14 percent of the electricity demand in 2050. Hence, it will be difficult to alter the basic situation in which coal is the major source of energy and electricity in China. Coal is abundant in China. Reserves total 796.2 billion tons. However, they are not evenly distributed. Approximately 62.4 percent (479.8 billion tons) is concentrated in Shanxi, Shaanxi and Inner Mongolia. With the exception that Xinjiang, Gansu, Ningxia, Qinghai and the southwest are self-sufficient, other regions must have coal shipped in. Especially in economically developed regions along the coast in eastern, northern and southern China, shipping has become a limiting factor due to the vast quantity and long distance involved. A coal-intensive energy structure aggravates air pollution and accelerates the greenhouse effect. It has an adverse impact on the ecology. This is another factor to be taken into consideration.

In conclusion, with existing technology, the best decision is to develop nuclear power which is cheap and clean. To have nuclear power carry substantial weight in our future energy load is the only way to alter our energy structure and alleviate the energy shortage.

Nuclear power has just begun in China. The first phase of the Qinshan power plant (300 MW) and the Daya Wan power plant in Guangdong (2 x 900 MW) are expected to be completed in the near future. Preliminary work on Phase 2 of the Qinshan power plant (4 x 600 MW) has also begun. According to the nuclear power development plan prepared by the Ministry of Energy Resources, 6,000 MW of nuclear power installed capacity will be ready by 2000. It will represent 2.6 percent of the total electric power installed capacity. By 2015, the total nuclear power installed capacity will rise to 30,000 MW, which represents 6 percent of the total capacity. Assuming nuclear power will represent 10-20 percent of the total capacity by 2050, the low and high rate nuclear power development curves as a function of year will be as shown in Figure 1. In order to meet this kind of demand for nuclear power, we should develop more fuel-efficient reactors, especially the fast breeder reactor.

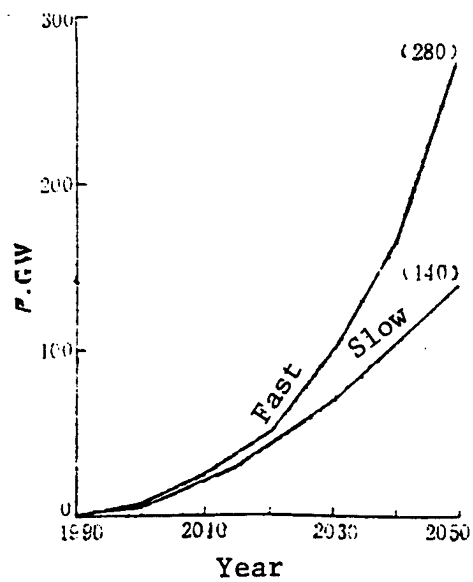

Figure 1. Forecast of Nuclear Power Development

III. Position and Role of FBR in Future Electric Utilities

1. Limitation of PWR

Thermal neutron reactors—including the pressurized water reactor (PWR), advanced pressurized water rector and high-temperature gas-cooled U-Pu cycle reactor—usually have a very low uranium utilization rate and consume a great deal of natural uranium. Corresponding to the calculated forecast of low and high rate development of nuclear power, the amount of the uranium required is shown in Figure 2. Table 3 shows the fuel utilization characteristics of PWR.

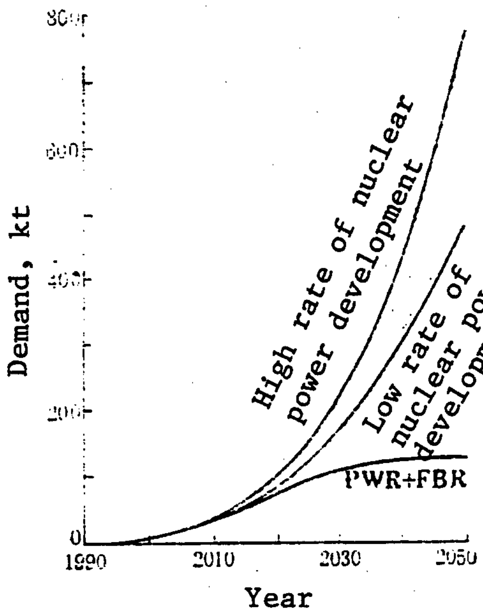

Figure 2. Cumulative Demand for Natural Uranium (PWR alone)

Table 3. Fuel Utilization Characteristics of PWR*

Consumption of unloaded fuel, MW-d/t		33,000
Conversion ratio		0.6
Initial load, t/GW	U-235	1.8
	Heavy metal	79.7
Balanced annual replacement, t/GW-a	U-235	0.804
	Heavy metal	25.1
Balanced annual removal, t/GW-a	U-235	0.216
	Fissile Pu	0.163
	Heavy metal	24.3
Lifetime (30 years) uranium demand, t/GW		4,162

*Load factor is 0.75.

It should be pointed out that the results shown in Figure 2 and Table 3 do not include the fuel required for existing power plants. Based on the fact that uranium is limited to 120,000 or 150,000 tons, PWR plants cannot be built after 2011 and 2014 if nuclear power development proceeds at the higher rate, or 2014 and 2017 if it follows the lower rate. The corresponding capacities are 28 and 36 GW, respectively (see Table 4).

Table 4. Limitation of Nuclear Power Development (PWR alone)

Natural uranium	Year PWR construction ceases		Nuclear power capacity limit, GW
	Low rate	High rate	
120,000 tons	2014	2011	28
150,000 tons	2017	2014	36

It will require a total of 583,000-1,166,000 tons of natural uranium to meet the nuclear power target of 140-280 GW in 2050. This is approximately 7-14 times the current reserve. It requires a reserve increase by an average of 12,000 tons per year, which is almost impossible.

2. Prospect of Nuclear Power Development With a Combination of PWR and FBR

(1) Fuel Utilization Characteristics of Commercial FBR

The FBR is still in a commercial demonstration stage. There is plenty of room for improvement in the commercial demonstration plant (SPX-1) that is in operation, and there is always some ongoing research and development. In particular, there has been a breakthrough in the development of a novel metal fuel (U-Pu-Zr), which may be commercialized in the near future. Therefore, the analysis is focused on both the mature oxide fuel and the novel metal fuel.

We have a serious energy shortage which requires the sustained growth of nuclear power at a faster pace. Hence, it is an objective need to bring in the FBR. The data in reference 3, as shown in Table 5, is used as the basis of this analysis.

Table 5. Fuel Utilization Characteristics of a Commercial (1 GW) FBR Power Plant*

Fuel type	Hybrid oxide fuel		Metal fuel (U-Pu-Zr)	
Fuel stay in reactor, a	2	2	2	2
Fuel stay outside reactor, a	2	1	2	1
Specific fuel (Pu) at core, kg/GW	3,158	3,158	2,488	2,488
Specific fuel (Pu) in system, kg/GW	6,315	4,736	4,977	3,732
Annual replacement (Pu), kg/GW-a	1,579	1,579	1,244	1,244
Annual removal (Pu), kg/GW-a	1,824	1,831	1,656	1,660
Breeding ratio	1.325	1.325	1.582	1.582
System doubling time, a	25.8	18.8	12.1	9.0

*Load factor is 0.75.

(2) Combined Development of PWR-FBR

Following the lower rate forecast and based on the 125,000-ton limit of natural uranium, the annual demand and cumulative demand for uranium, accumulation of plutonium based on the PWR development model, and the separation power requirement will be as shown in Table 6.

Table 6. PWR model, Pu Accumulation, Demand for Natural U and Separation Power

Year	PWR power, GW	U demand cumulative, kt	U demand annual, kt/a	Accumulated Pu, t	Annual separation power, kt/a
2000	6.0	7.2	1.36	3.25	0.92
2005	14.0	17.4	2.44	9.88	1.74
2010	22.0	30.7	3.46	22.59	2.55
2015	30.0	52.5	3.92	41.83	3.05
2020	30.0	71.6	3.81	66.02	3.04
2025	27.0	89.3	3.39	89.88	2.73
2030	24.0	105.1	3.01	111.39	2.43
2035	16.0	116.8	1.93	129.49	1.61
2040	8.0	123.4	0.91	141.22	0.80
2045	0	124.9	0	146.44	0
2050	0	124.9	0	146.44	0

From the standpoint of developing nuclear power to the largest extent possible, the optimal model for using the FBR is to finish fuel (Pu) preparation and technology preparation at the same time. This means that the scale of FBR development is totally determined by the amount of Pu accumulated and by the performance of FBR and is not limited by the degree of technical preparation. Obviously, this is an ideal case. Figure 3 [not reproduced] shows the calculated scale of nuclear development in 2050 based on this assumption.

As can be seen, the breeding difference of oxide fuel and metal fuel has a significant impact on the scale of nuclear power achievable in 2050. Reducing the stay of fuel outside the reactor is very important. Considering the fact that the research and development period is relatively long between now and the point where the FBR can be commercialized on a large scale, the introduction of FBR power plants might be further delayed due to lack of technical preparation or other reasons, and power plant performance might have to be lowered somewhat. The mixed oxide fuel cannot meet minimum targets set for nuclear power development in 2050. It is appropriate to choose the metal-fueled FBR as the direction of development.

In reality, the most probable case is that the commercialization of the FBR will not be determined by the preparation of Pu. Instead, its introduction will be delayed due to lack of technical preparation. Table 7 shows the effect of introducing the metal-fueled FBR in 2015, 2020, 2025 and 2030 and the effect of fuel stay outside the reactor for 1 and 2 years on the scale of nuclear power development. The calculation assumes that the rate of introduction is 1 GW in year 1, 2 GW in year 3, 4 GW in year 5,....., until reaching the limit of plutonium supply. From Table 7, we can see the significance of bringing the FBR on line as early as possible.

Table 7. Effect of FBR Delay on Nuclear Power Development in 2050 (GW)

Year of FBR on-line	Stay outside reactor, a	
	2	1
2015	225	621
2020	201	376
2025	123	260
2030	96	170

IV. Conclusions

(1) Our energy and electricity supply is very tight. It is difficult to change our long-term energy structure which is centered around coal. Coal-burning power plants are generating very serious transportation and pollution problems. In order to alleviate this dilemma and alter the energy structure, we must develop alternative energy sources as early as possible. To date, nuclear power is the most reliable, economical, clean and advanced alternative.

(2) Based on the availability of uranium in China, thermal nuclear power plants alone account for a very small proportion, far below the long-range demand for nuclear power.

(3) If the FBR is developed as early as possible based on our development of thermal nuclear power, with a supply of approximately 120,000 tons of natural uranium, our nuclear power output may reach 140 GW by 2050. This is 10 percent of the total electric power requirement. Nuclear power can play a meaningful role

in altering our energy structure. Particularly for coastal developed ares where the demand for electricity is high and energy resources are poor, nuclear power is of even greater significance.

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CRACBJ Model Description

926B0070A Beijing HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 13 No 1, Feb 92 pp 38-42

[Article by Shi Zhongqi [2457 0112 7871] of the Institute of Nuclear Energy Technology of Qinghua University: "CRACBJ Model Description"; MS received 5 Jan 91, revised 25 Jul 91]

[Text] **Abstract**: CRACBJ is a risk assessment program for the Guangdong Nuclear Power Plant. It is written based on the CRAC2 program. This paper discusses the purpose of the modifications made, major contents of modifications and its adaptability to the plant site. In addition, it also presents the VAX versions of CRACBJ and CRAC2.

Key words: nuclear accident, consequence analysis, probabilistic safety assessment, atmospheric dispersion.

I. Introduction

The CRACBJ program, which is used for consequence and risk analysis (i.e., accident consequence assessment, or ACA) to meet the Guangdong Nuclear Power Plant Probabilistic Safety Assessment (GNPSA) requirements, is a modification of the U.S. CRAC2[1] program. There are no changes to the basic structure of CRAC2. With the exception of a few items to suit the GNPSA output, the input format is also virtually untouched. The unedited CRAC2 program is the 1984 revision for the CDC mainframe computer. The mode and operation of CRAC2 are discussed in detail in references 1 and 2.

The purposes of modifying CRAC2 are as follows: (1) to include the geographic and climatic characteristics of the site—in addition to replacing the permanent weather file, major modifications were made to the source code; (2) to absorb technical progress made in the field of ACA since CRAC2 was released to reflect several internationally accepted emergency response principles (since emergency response can critically impact consequences and risks); and (3) to match the source output of GNPSA.

II. Explanations Associated With CRACBJ

1. Atmospheric Dispersion Parameters

Atmospheric turbulence has two sources, i.e., mechanical and thermal. The topography of the site is one of the principal mechanical factors causing turbulence. Atmospheric dispersion parameter σ_y and σ_z are closely dependent upon the ground roughness Z_o.

Daya Wan (Daya Bay), the plant site, has a complicated topography. On the north, there are hills on the Dapeng peninsula. There is a 700-m-high mountain 3 miles to the north. The land portion of the plant site has the characteristics of rolling hills. The CRAC2 program, however, uses the atmospheric dispersion coefficient for a typical nuclear plant site in the United States. Although a rough correction has been made to the standard P-G dispersion parameters (from Z_o = 3 cm to Z_o = 10 cm), the question of whether it is appropriate for Daya Wan yet to be answered.

Since no atmospheric dispersion experiment has been done at the plant site, no directly applicable parameters are available. Two major conclusions can be drawn from related data:

(1) Based on the weather data gathered at Dakeng,[3] the site of Suzhou Thermal Plant, the ground roughness is of the order of meters, which is far greater than the Z_o used in CRAC2.

(2) According to the wind tunnel experiment done in France over a 5 km radius around Daya Wan, under neutral weather conditions and with a 68.5-m smoke stack, the ground concentration is 2-4 times higher than that calculated by a conventional program.[4]

Although it is not possible to directly obtain the atmospheric dispersion parameters at Daya Wan from the data discussed above, the type of parameters that should be used in the ACA program can be determined based on the actual topography of the site and the data given in those two studies.

In addition to field test and wind tunnel experiment, there are three other methods we can use to handle highly rough hilly terrain in meteorology.

(1) Shift atmospheric stability (as defined by the Pasquill method) toward the direction of instability, such as that specified in the State Environmental Protection Bureau's Domestic Standard GB3840-83, pertaining to the requirements for σ_y and σ_z for a hilly terrain.

(2) Use atmospheric dispersion parameters measured in a highly rough terrain. The IAEA[5] and our National Nuclear Safety Administration's Guideline HAF0103 recommend the use of a set of parameters measured in Germany.[6]

(3) Treat roughness as a variable in calculating atmospheric parameters. Different parameters[7] are chosen for different Z_o.

Considering the fact that no ground roughness has been accurately determined at Daya Wan, based on the topography of the site and the available data, we employed method 2 for the sake of convenience. The CRAC2 source code was modified using a set of dispersion parameters (see Table 1) measured at a medium to high roughness ($Z_o = 1$ m). When using the CRACBJ program (with dispersion parameters corresponding to $Z_o = 1$ m) in GNPSA, the risk of acute death within a radius of 0.5 km around the reactor is 50 percent higher than that with $Z_o = 0.1$ m (which is the original value in CRAC2). Since the selection of such parameters is not experimentally verified, the parameters used in CRAC2 are still used for comparison in risk analysis.

Table 1. Dispersion Parameters Associated With Medium to High Ground Roughness*[5,6]

	Atmospheric stability type					
	A	B	C	D	E	F
P_y	0.87	0.87	0.72	0.62	1.69	5.38
Q_y	0.81	0.81	0.78	0.77	0.62	0.58
P_z	0.22	0.22	0.21	0.20	0.16	0.40
Q_z	0.97	0.97	0.94	0.94	0.81	0.62

* $\sigma_y(x) = P_y X^{Q_y}$, $\sigma_z(x) = P_z X^{Q_z}$, X is the distance from the source (m).

2. Parameters in the Lift Equation

In a serious accident involving core meltdown or safety containment failure, the leakage of radioactive matter is often accompanied by the release of a large amount of heat. Thus, it causes the release height to rise. The lift of hot smoke and steam is directly related to the surrounding atmosphere. The CRAC2 program assumes that the temperature is 6°C. This might be because stable weather conditions (type E and F) usually occur at night. Daya Wan is located in southern China, where the temperature is higher. The average nighttime temperature in 1985 was 21.3°C. In CRACBJ, stability parameters calculated based on the temperature at Daya Wan are used to replace the corresponding values in CRAC2. This change of temperature makes the lift height corresponding to type E and F weather decline by approximately 20 and 10 percent, respectively. In the event of a short-term discharge, when the discharge height is 80 m, the maximum ground concentrations under weather condition E and F are 80 and 40 percent higher, respectively, than those with a 100-m discharge height (based on P-G dispersion parameters).

3. Wash Factor

The fraction of nuclei removed by wet precipitation, f_w, is calculated using the following formulas:

$$f_w = 1 - \exp(-\Lambda t_i)$$

$$\Lambda = cR$$

where Λ is the wash factor in units of s^{-1}, R is the rainfall in units of mm/h, and c is a constant in units of h/mm-s.

In CRAC2, the constant c is dependent upon atmospheric stability. Based on more recent research, c is independent of stability and is usually chosen to be 1×10^{-4} h/mm-s.[8]

4. Emergency Response

(1) Evacuation Plan for Residents

In the CRAC2 emergency response model, one can choose between two plans for early-stage evacuation of personnel after a leak. One is to evacuate within a certain period after the radiation fallout hits the ground. The other is to evacuate 7 days after the radiation fallout reaches the ground. If the 7-day bone marrow dosage exceeds 2 Gy (200 rem), then evacuation takes place within 24 hours. CRACBJ modifies the irradiated organ and dose standards specified by CRAC2 based on the emergency evacuation and relocation intervention levels recommended by IAEA.[9] When the overall dose due to external radiation in 7 days exceeds 0.5 Gy (50 rem), evacuation must take place in 24 hours. 0.5 Gy is the upper intervention limit for evacuation (and relocation). When the overall dose is greater than 0.5 Gy, evacuation is mandatory.

(2) Maximum Ground Decontamination Factor

CRAC2 takes long-term ground radiation into account. If such long-term dose exceeds the specified limit, the model determines whether ground decontamination is necessary in order to lower it to an acceptable level. The CRAC2 source code uses 20 as the maximum decontamination factor. After taking the Chernobyl accident into consideration,[10] it was modified to 10 in CRACBJ. In CRACUK, a British ACA program, it is chosen to be 3. This change will increase the area of land that will be permanently banned for any use after an accident in order to reduce the long-term collective dose.

5. Input and Output

(1) Input Changes

In the original CRAC2 source code input, 54 isotopes are divided into eight groups. In CRACBJ, they are divided into 10 groups based on the 2nd-level output source terms of GNPSA. Ba and Ce are removed from the Sr and La groups, respectively, to improve the accuracy of computation.

(2) Output Changes

CRAC2 divides the area within an 800-km radius surrounding the power plant into 16 sectors and 34 rings. Since even in the event of a very serious accident, the consequences outside an 80-km radius are considered to be minimal, and furthermore, to be consistent with the population distribution around the plant, GNPSA only assess consequences within an 80-km radius. This area is divided into 16 sectors and 13 rings. Hence, it was necessary to modify the source code to change the spacing accordingly.

The original output provides the number of people that receive more than a 2 Gy (200 rem) bone-marrow dose. This was also modified. Other than modifying the source code, changes are also necessary in the input.

6. Permanent Data Files

(1) Weather Data File

CRACBJ provides a weather data file for Dayawan based on the observation made at the Dakeng site, including wind direction, wind-speed atmospheric stability and rainfall as a function of time, as well as seasonal mean mixing layer heights.

(2) Dose Conversion Factor File

Based on new dose conversion data,[11] we wrote a new dose conversion factor file TAPE21. However, in view of the fact that most new factors are smaller than their original values and the new factors are not complete yet, the original TAPE21 file is still used in GNPSA.

7. Suitability of Atmospheric Dispersion Model in CRACBJ

In CRACBJ, other than the fact that the actual site has been taken into consideration in the weather file, atmospheric dispersion parameters and stability parameters, there are two more issues associated with the suitability of the atmospheric dispersion model: i.e., the linear model and the fact that the coastal characteristics of the site have not been taken into account.

(1) Comparison of Linear Model and Trajectory Model

CRACBJ uses a linear atmospheric dispersion model which is similar to that in most PSA programs. In computing such weather sequence, only the wind speed change in the first hour is considered. It does not take into account any wind direction change during the discharge and dispersion period. Rigorously speaking, the linear model is only applicable in ideal atmospheric condition with a homogeneous and stable turbulent flow field. In some recently developed ACA programs, a trajectory model is used for atmospheric dispersion. The change of wind direction is taken into consideration to calculate the time and space dependence of smoke. The trajectory model obviously is more consistent with the real weather situation, especially in the complicated terrain at the plant site. Hence, it is necessary to analyze the difference between the two models in post-accident assessment. The trajectory model has two major factors affecting the consequence. One is that because wind direction change is considered, the concentration of radioactive material disperses over an even larger area, leading to a smaller peak compared to that of the straight line Gaussian model. The entire polluted area will increase. Next, because the smoke is curved, it takes longer to reach a distance away from the plant compared to the straight line model. This makes radiation precipitate over a larger range of area and increases the probability of evacuation. Studies show that the trajectory model predicts 25 percent less early-stage fatalities compared to the straight-line model. However, the number of people needing to be evacuated is 30 percent higher. The area contaminated with a 1 mSv/a 50-year cumulative dosage will also increase significantly.[12] On the average, the 20-km total contamination area will double. The number of delayed random deaths will also increase by 100 percent. This is because the number of people that need late-stage protection (e.g., decontamination, banning from eating and drinking contaminated food and water) is decreased due to exposure to a lower-than-specified dose limit.[13] Besides, the trajectory model needs more computing time. The study done by J. A. Jones et al. shows that the CPU time will increase by a factor of 10.[12] After considering various factors, their conclusion is that the straight-line model is still suitable for most PSA applications.[12]

(2) Effect of the Coastline

Dayawan is located by the sea. The effect of the land-sea interface on atmospheric dispersion has been described by several models. A study on the effect of the seacoast on the consequence[14] shows that, in a short range, the seacoast alters the concentration distribution, especially the concentration distribution surrounding the most concentrated point on land. However, on a larger scale, there is little difference between an inland site and a coastal site as far as projected concentration is concerned. Hence, it is rational to conclude that the coastline has no significant impact on atmospheric dispersion within the context of PSA.[14]

III. VAX Versions of CRACBJ and CRAC2

CRACBJ and CRAC2 have been ported to the VAX minicomputer. The VAX versions provide many cities and organizations without a CDC mainframe computer with a tool for estimating accident consequences. From the results obtained with standard examples and the ACA applications in Guangdong, both CDC and VAX versions of CRACBJ and CRAC2 are reliable.

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Developing the 'Fifth Energy Resource'

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[Article by Huang Shaoping [7806 4801 1627] and He Xiangmei [6320 7449 2734]: "Development of 'The Fifth Energy Source'"]

[Text] Everyone in the world is profoundly aware that energy conservation is "the fifth energy source" after the four main energy sources: petroleum, coal, water energy, and nuclear energy. In 1986, the International Energy Organization published a comprehensive report summarizing major accomplishments in the conservation of energy by the 19 major developed countries in the world during the 12-year period 1973-1985. Their principal conclusion was that structural methods for conserving energy can be realized through progress in technology, i.e., a change from high energy consumption to low energy consumption industry. This road enables these countries to get through energy crises smoothly, and it gives powerful impetus to their development side-by-side of technology and experience.

During the 1980's China's energy industry scored remarkable achievements under guidance of a policy of "adhering to equal emphasis on development and conservation," becoming the third largest country in the world in energy production and use. Nevertheless, China is still a long way from meeting energy needs for economic development and the people's daily lives.

Energy Situation Exceedingly Serious

1. Energy Reserves "Abundant in the Aggregate, Insufficient in Per Capita Terms, and Unevenly Distributed"

Eighty percent of China's coal is concentrated in north China and in the "three wests" area [meaning, presumably, the northwest, west, and southwest], which means that coal from the west must be shipped to the east, and coal from the north must be shipped to the south. Today, 40 percent of the nation's transportation is used to haul coal. Seventy percent of the country's water energy resources are concentrated in the southwest, necessitating the delivery of electric power from the west to the east.

Although China has plentiful energy overall, because of its large population, energy resources are in fairly short supply, mineral energy (coal, petroleum, and natural gas) amounting to only one-half the world, one-seventh the USSR, and one-fourth the United States per capita amount. Petroleum resources are in even shorter supply, per capita reserves amounting to only one-ninth the per capita amount of world reserves. China's per capita consumption of energy is very low at approximately 840 kilograms of standard coal per year, which is only one-third the world average. In 1989, China's per capita consumption of electricity was 500 kWh per year; in industrially developed countries it was 10,000 kWh per year.

2. Conflict Between Energy Supply and Demand

Experts estimate that China has had an annual 50 billion kW electric power shortage, a 30 million ton coal shortage, and a 10 million ton petroleum shortage for some time. Due to the energy shortage, approximately 30 percent of the country's industrial production capacity has gone to waste. The energy shortage, particularly the electric power shortage, has meant a sustained electricity shortage nationwide for 20 years. The sudden energy shortage of a structural nature that occurred in June 1988 posed a serious threat to the entire country's socioeconomic development. Forty percent of the country's industrial production capacity lay idle because of the shortages of energy and of raw and processed materials. This caused a loss of 400 billion yuan in output value and 50 billion yuan in profits and taxes for the year. Since the last half of 1989, the country's energy situation has changed somewhat. Coal is no longer in as short supply as formerly, the amount on hand rising; and electricity supply problems have eased in some areas. Nevertheless, these are temporary situations resulting from a slump in national economic development and insufficient work for quite a few industrial enterprises. The country's energy shortage situation has not changed fundamentally.

The last 10 years of this decade are a crucial 10 years for attaining the first step strategic goals in China's modernization. Intensive basic industries such as agriculture and energy, as well as communications and transportation will be substantially developed; the people's standard of living will reach a comfortably well-off level, and energy supplies will greatly increase. "The 10-Year Plan and the Eighth 5-Year Plan Programs for National Economic and Social Development" that the Fourth Meeting of the Seventh NPC passed provide for an energy output in 1995 equivalent to 1.17 billion tons of standard coal for an annual 2.4 percent increase; an energy output in 2000 equivalent to nearly 1.4 billion tons of standard coal, for an annual 2.7 percent increase, and an annual 6 percent growth in GNP. Clearly, the speed of increase in energy production is lower than the speed of national economic growth. Calculations based on the current high level of consumption show that by 2000 an energy supply equivalent to 1.74 billion tons of standard coal will be needed.

3. Challenges That the Energy Situation Is Facing From Environmental Problems

Coal constitutes 76 percent of China's energy consumption, 2.7 times the average world level. This energy structure in which coal is paramount is facing challenges from environmental problems. The overly large percentage of coal consumed not only creates transportation shortages, but the large amount of direct use of coal also produces low energy utilization efficiency that causes serious environmental pollution. Reportedly, soot from the burning of coal in China accounts for 73 percent of all effluent, for 90 percent of the sulfur dioxide, for 85 percent of carbon dioxide, and for more than 50 percent of nitrogen oxide. In addition, in China's rural villages where energy consists mostly of biomass, 75 percent of which is firewood and plant stalks and stems, approximately 300 million tons (actual amount) of firewood is burned each year. This is nearly three times a rational amount of firewood gathering, and it damages the ecological balance.

4. Energy Development Limited by Many Factors

The development of energy today is limited not only by what the country's financial resources, material resources, and technological level can bear, but also by serious population, resources, transportation, and environmental restraints. For example, the amount of investment required in China to get the same 1 kW of electric power is between 2,000 and 3,000 yuan for thermal power, 4,000 yuan for hydropower, 8,500 yuan for nuclear power, and between 25,000 and 40,000 yuan for solar power. By contrast, an investment of only between 300 and 900 yuan is required to conserve the same 1 kW of electric power.

To summarize the foregoing, the conservation of energy is a major problem in development of the country's national economy and society. China must implement an energy-conserving development strategy.

Enormous Energy Conservation Potential

Statistics are frequently dry, yet they illuminate problems.

Even though China scored very great accomplishments in energy conservation during the 1980's, the problems of a low energy utilization rate, high energy consumption per unit of product, and poor economic returns have not changed fundamentally. By comparison with advanced countries, the gap is very large. This also shows the existence of an enormous energy conservation potential in China.

1. Macroeconomic Returns Poor From Energy Use

Statistics for 1988 from the World Resource's Institute in Washington and London on 10 major economic powers (not including the USSR) show China highest in energy consumption for GNP figured in United States dollar units, five times that of France and Japan, 3.4 times that of the UK, three times that of Brazil, and 1.6 times that of India.

Pursuit of speedy growth in output value over a fairly long period of time at the expense of energy conservation in the building of China's economy has resulted in a very high energy investment coefficient. For every 10,000 yuan of GNP in 1990, the energy equivalent of 9.3 tons of standard coal was consumed. Even though this was 30 percent lower than the 13.36 tons of standard coal consumed in 1980, it was still rather high.

2. High Consumption Per Unit of Product

Even though energy consumption per unit of product declined for nearly two-thirds of more than 60 different major products surveyed during the 1980's, energy consumption per unit of major products produced in China today remains very high. The waste of energy is serious. For example, energy consumption per ton of steel produced in China's main steel concerns was 30 percent higher than for major steel producing countries during the early 1980's.

3. Low Energy Utilization Rate

Relevant data show an energy utilization rate for China of only 32 percent, which is approximately 18 percentage points lower than for developed countries. This means a potential for saving the equivalent of more than 300 million tons of standard coal exists today in total energy consumption, which is calculated to be 1 billion tons of standard coal. (Figured at projected total consumption in 2000, the energy conservation potential is equivalent to approximately half a billion tons of standard coal.) Even by increasing the energy utilization rate 1 percentage point, 30 million tons of standard coal could be conserved.

The foregoing analysis shows a very great potential for energy conservation in China. This potential may be found largely in thermal energy power plants, electricity transmission, and machines that consume petroleum, as well as in energy used in production and in daily life. In the electrical industry alone (power generation, power transmission and transforming, and industries that use electricity), China loses more than 10 percent of its electric power in transmission and transforming. (In Japan, the percentage has fallen to 6.) Figured on the basis of the transmission of 600 billion kW of electricity in 1990, the annual loss of electricity in the transmission and transforming process was 60 billion kW. Attainment of the level of Japan would mean the annual conservation of 24 billion kW. Electric boilers are large industrial consumers of electricity. Statistics show the consumption of approximately 30 billion kW of electricity by all kinds of electric boilers nationwide. This is approximately 7 percent of the total amount of electricity generated nationwide in recent years. With technological transformation, efficiency could be greatly increased. Experts estimate the potential for electricity conservation in the country's electrical industry at more than 80 billion kW.

Development of the fifth energy resource—energy conservation—requires little investment, shows quick results, has a short capital turnover time, and produces high returns. Therefore, "adherence to equal emphasis on development and conservation," and a policy of energy conservation is absolutely no expedient measure, but a long-range national development strategy.

The energy conservation potential is very great, but can China's technological level support the heavy burden of energy conservation? Do we have the gumption to reach the energy conservation goals of the 1990's? Yes, we do!

Technological Means of Conserving Energy

Experts feel that for the near-term, China's energy conservation technology should stress the following main aspects of the problem:

1. Increase the heat energy utilization rate. The emphasis should be on improving the heat efficiency rate of the nation's industrial boilers and industrial kilns and furnaces, which consume 65 percent of the nation's energy, developing joint production of heat and electricity, centralizing the supply of heat, and improving efficiency of the heat supplying systems.

2. Increase the electric energy utilization rate. The emphasis here should be on the following: Increasing the operating efficiency of systems in which machinery and electrical appliances such as blowers, water pumps, and electric motors are used; developing electric energy saving technology, particularly electric power and electronic energy saving technology; and saving electricity by technological equipment that consumes high amounts of electricity to produce products such as electric steel, ferroalloys, electrolytic aluminum, calcium carbide, caustic soda, synthetic ammonia, ethylene, yellow phosphorous, and cement.

3. Vigorous spread to application of new technologies, new techniques, new equipment, and new materials. Examples include continuous casting, rich oxygen injection, ionic membrane sodium hydroxide production, synthetic ammonia self-supplied steam ("converting two coals into a single coal"), cement decomposition ex-kiln, and cement block manufacture.

4. Increase in coal cleaning and processing, and the percentage of such coal used in electric power generation.

5. Multiple uses of resources. Multiple use of low thermal value fuels, recovery for use of waste heat, waste energy, ashes, and sediments; better recovery and use of discarded materials.

6. Replacement of antiquated transportation equipment with low energy consuming, highly efficient transportation equipment. Examples include the use of electric and internal combustion locomotives in place of steam locomotives, and use of diesel vehicles in place of gasoline vehicles.

7. Using petroleum instead of coal. Reduced burning of oil in power station boilers and kilns, and reduced use of oil available to oil fields, oil refineries, and petrochemical plants. Development of coal gasification, liquification, coal slurry processes, and clean coal technologies in an effort to find the best economics of technology methods to replace premium sources of energy.

8. Development of kinds of coal for use in the daily life of the people in cities and towns, developing coal gas for use in some large and medium size cities where conditions permit. In northeast China, north China, and northwest China, every effort should be made to provide heat from central installations.

9. Improve the use of energy in the daily life of rural people. The principles of "suiting general methods to specific circumstances, the complementary use of many different kinds of energy, multiple use of energy, and emphasis on results" should be followed in the vigorous spread of firewood-conserving and coal-saving stoves, energetic firewood forest afforestation, active and steady development of methane gas, and accelerated building of small hydropower facilities. Development for use of renewable energy technology, improving the energy self-sufficiency rate by promoting a benign cycle in energy.

10. Better energy-saving construction. Emphasis should be placed on improving the composition of walls, on heat ventilation, on heat supply control, and on temperature control.

11. More study of soft science and technology. Development of applied systems engineering techniques and computer techniques to the scientific management of resources conservation and multiple use of resources, information exchange, and energy conservation forecasting and planning.

To summarize the foregoing, development of the fifth energy resource is not only extremely necessary, but also both technologically and economically feasible. It is hoped that national government agencies will make sure that energy conservation work will be done when drawing up policies.